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# PRODUCTION AND CONSUMPTION OF FOODGRAINS IN INDIA: IMPLICATIONS OF ACCELERATED ECONOMIC GROWTH AND POVERTY ALLEVIATION

J. S. Sarma
Vasant P. Gandhi

July 1990

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# FOREWORD

The role of agriculture in India's economic development continues to be of great importance, as a producer of food, as an employer of about two-thirds of the labor force, and as a source of purchasing power for much of the nonagricultural consumer goods and services in the economy. Thus, rapid growth in agriculture is essential for sustainable growth and development of the economy.

Within agriculture, foodgrain production is by far the major activity, covering about 80 percent of the cropped area in India and providing the main staple source of food. Foodgrains provide almost all the calories and proteins consumed by the poor and provide the rural poor with the bulk of their employment and income. Further, with a population of some 800 million people, what happens to India's foodgrain supply-demand balances has important implications for the global balances. That will be particularly so as India continues to accelerate its overall rate of growth of per capita income.

Government policy in India has always given substantial importance to foodgrain production. Such support, particularly since the beginning of the green revolution in the mid-1960s, has contributed to remarkable growth in this sector despite many constraints. Yet with a growing population, rising incomes, and the substantial latent demand of the poor for foodgrains, the country will require continuing high growth in production.

The past performance and future prospects of Indian foodgrain production and consumption are of considerable importance in Third World and global food considerations. India, which faced food deficits till the mid-1970s, became self-sufficient or marginally surplus thereafter; but even with this remarkable food production performance, rapid economic growth and poverty alleviation have not been achieved. The implications of the achievement of these goals, say by 2000, on the food demand are not very clear, considering the interlinkages between the growth in foodgrain production and that in consumption, particularly in the rural areas. India is fortunately endowed with data that enable these implications to be analyzed.

In this study of foodgrains in India, J. S. Sarma and Vasant P. Gandhi critically examine past growth and performance in foodgrain production as well as developments in the growth and patterns of foodgrain consumption. The study finds that rapid growth in foodgrain production will be necessary but extremely demanding, especially in the context of the dual objectives set by Indian planners—acceleration of economic growth and alleviation of poverty. Within agriculture, these objectives will require not only rapid increase in foodgrain production but even faster growth, through diversification, in the nonfoodgrain sector, including livestock production and horticultural crops, in which income elasticities of demand and employment potential are high. However, even an impressive performance may leave foodgrain deficits that would require imports and an appropriate development strategy if accelerated economic growth and poverty alleviation are to be achieved.

The International Food Policy Research Institute has developed a collaborative research program on the future growth in Indian agriculture under a memorandum of understanding with the Indian Council of Agricultural Research and with funding from the United States Agency for International Development. The overall objective of the research program, undertaken in collaboration with research institutions and scholars in India, is to contribute toward increased understanding of the options and complexities in the future policies for agricultural growth. The present study is a step in this direction. We expect its results to be useful in the policy formulation processes, not only in India but also in other countries, especially since India's richness in data and experience allows analysis that may be difficult to duplicate elsewhere.

John W. Mellor

Washington, D.C.
July 1990

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# 1

# SUMMARY

India has shown an impressive agricultural performance since the mid-1960s. The increasing shortages and inability to cope with growing food demand at that time gave way in the 1980s to occasional marginal surpluses. There are, however, grave doubts on several issues—a major worry being the trend in the growth of foodgrain production, which, according to some studies, shows deceleration in the recent past. This raises questions about the sustainability of the growth and an exhaustion of the potential of the "green revolution." There is also concern that the growth in production has had a narrow geographic and crop base and that substantial production growth may not be possible in other regions and crops. Serious doubts have also emerged about the productivities of modern inputs, which are used in increasing quantities to sustain growth. There is concern about whether these productivities are declining and, if so, whether they will continue to decline, making future growth both difficult and expensive. Yet another puzzle is the emergence of foodgrain surpluses (in the form of large government stocks) with coexisting hunger, even in the wake of impressive agricultural growth.

This study addresses these concerns by analyzing the nature and pattern of past growth in foodgrain production and consumption, using national and regional data on foodgrains. It uses this analysis to carefully extrapolate into the future, examining the prospects for growth in foodgrain production and how these compare with the likely levels of foodgrain consumption in the future. The Government of India has set for the year 2000 the twin principal objectives of acceleration of economic growth and elimination of poverty. The study examines the implications of these objectives for the foodgrain situation and the resulting demands on food and agricultural policy in India.

In examining the growth rates in several subperiods since the early 1950s, the study finds that the growth rate of foodgrain production declined somewhat from the pre-green-revolution period (1949/50-1964/65) to the first half of the green-revolution period (1967/68-1975/76), but from the first to the second half of the green-revolution period (1975/76-1983/84) the growth rate showed a modest acceleration from 1.9 percent to 2.5 percent a year. The overall growth rate for 1949/50-1983/84 was about 2.6 percent. This shows that the growth rate of foodgrain production has recovered and is being sustained.

Comparing the period of the early 1950s to mid-1960s with the mid-1960s to early 1980s, there was a sharp decline in the latter period in the growth rate of foodgrain area, indicating its declining potential. Yield-based growth, however, has sharply increased in importance, contributing over 90 percent of the growth in production during 1975/76-1983/84. Analysis shows that most of the yield-based growth came from wheat and rice—particularly wheat, whose average yield increased two and a half times between the early 1950s and early 1980s. At the national level, growth in the yields of individual crops has been of major importance behind the growth in overall yields and production of foodgrains. This indicates the criticality of policies for sustaining yield- and technology-based growth in the future.

Growth in foodgrain production shows much regional diversity, but this is changing. The rapid growth in the Northern region continues to accelerate, driven by increasing wheat and rice yields and diversion of area from coarse grains and pulses to wheat and rice. In 1975/76-1983/84 the Uttar Pradesh region showed a large increase in the growth rate of production, thus raising it almost to the level of the Northern region. This was also substantially due to increases in wheat and rice yields and diversion of area from coarse cereals and pulses to wheat and rice. The Central region also showed a large increase in the production growth rate in this period, distributed over wheat, rice, and coarse cereals.

On the other hand, the Western, Eastern, and Southern regions showed declining growth rates of foodgrain production. The Western region's decline appears to be mainly due to poor rainfall during 1975/76-1983/84 and possibly to little new, promising technology for the dryland agroclimatic regime. The Southern region's decline was largely due to diversion of area away from foodgrains—its yield growth stayed unchanged. The Eastern region's growth rate continued its decline, turning negative in this period, but the yield growth rate showed a small upturn. A common feature of foodgrain production in these three regions is that the growth rates of cereals declined sharply, whereas the growth rates of pulses remained relatively high and positive. The analysis shows that growth in foodgrain production now comes from a wider regional base than just the Northern region, that it is critically yield-based, and that the recent acceleration appears to be associated substantially with rapid increase in input use, particularly fertilizers.

Examination of all-India input use levels shows large increases in recent years. Among the major inputs, irrigation (gross irrigated area) shows a relatively steady increase, and high-yielding varieties (area under HYVs) shows a very impressive growth until the mid-1970s and then some deceleration. Fertilizer use shows substantial acceleration in the late 1970s and early 1980s. Analysis indicates a decline in the aggregate input productivities between 1969/70-1971/72 and 1981/82-1983/84, apparently beginning around 1977/78. The decline in input response, particularly aggregate fertilizer productivity, may be due in part to persistent concentration of input use in some areas and poor management toward maximizing response in others. This calls for considerable attention from both policymakers and researchers.

From the early 1950s to the early 1980s, the per capita availability of foodgrains for human consumption, on a three-year moving average basis, has fluctuated within a narrow band of 150-170 kilograms a year, with a statistically insignificant trend. Thus, foodgrain production growth seems to have been largely absorbed by population growth, reduction in imports, and increase in stocks. National Sample Survey consumption data indicate a small improvement in the distribution of total expenditure (income) between 1977/78 and 1983 in both the rural and urban areas, and between the rural and urban areas. For the poor population, the data indicate that foodgrain consumption of the rural bottom quartile rose somewhat between 1970/71 and 1983, but that of the urban bottom quartile was virtually stagnant. This is associated with a small increase in the real total expenditure (income) of the rural bottom quartile but near stagnation in that of the urban bottom quartile. The positive effect of development on the rural bottom quartile, though, seems to have been partly annulled by adverse movement of relative foodgrain prices for them.

The overall income elasticities of foodgrain demand are estimated to be 0.48 for rural, 0.23 for urban, and 0.42 for national, but elasticities differ sharply by quartile, being close to 1.0 for the bottom quartiles and about 0.1 for the top quartiles. Viewed in conjunction with the income growth patterns, these figures indicate that a major reason for India's direct foodgrain consumption not increasing more rapidly is that development appears to have had too little effect on raising the incomes of the poor, who have high income elasticities of demand for foodgrains.

Broad calculations and experience from other developing countries indicate that demand for animal feedgrains may rapidly become a major component of growth in the total demand for foodgrains. Livestock output grew at a rate of 4.33 percent a year between 1970/71 and 1984/85, and such a trend may result in a derived demand growth of 5-6 percent a year for feedgrains.

Assuming substantial government emphasis on agriculture, it is possible that past performance in production may be extended into the future. Region by region, crop by crop, area and yield projections on foodgrain production, based on growth rates from 1967/68 to 1983/84 with some necessary restrictions, show that the total production of foodgrains in India by the year 2000 may reach about 220 million metric tons. Different, more aggregative methods of projection indicate possible foodgrain production of 210-215 million tons by year 2000. Achievement of these production levels will, however, be a formidable task and is estimated to require 100 million hectares of irrigated area, 20 million tons of fertilizer (NPK) use a year, and production and distribution of 6 million tons of HYV and improved seeds. It will also require a substantial government commitment to technology-based growth in agriculture.

On the consumption side, the study made particular efforts to examine the implications of the twin objectives set by the Indian planners—acceleration of economic growth and elimination of poverty by 2000. Results showed that the foodgrain consumption (demand) outcome in 2000 can vary from 206 to 240 million tons including seed, feed, other uses, and wastage. The analysis showed that the development outcome could make a large difference in the foodgrain situation in 2000, ranging from India's becoming either self-sufficient or surplus in foodgrains to becoming significantly deficit and an importer. The estimates show, in particular, that achieving the twin objectives is likely to have a substantial impact on the demand for foodgrains. This will call for unrelenting efforts to increase foodgrain production and productivity. But even a remarkable performance on the production side, amounting to a 2.8 percent a year growth rate in foodgrain production compared with 2.6 percent in the past, may still leave a large supply-demand gap and a sizable need for imports. This will in turn call for an open mind toward imports, political courage to make them, and an appropriate economic strategy to support them if acceleration of economic growth and poverty alleviation are to be achieved.

# 2

# INTRODUCTION

In the past 25 years the foodgrain situation in India has undergone substantial change. From a position of growing shortages in the mid-1960s, India became able in the 1980s to produce enough to meet its current demand and sometimes generate a small surplus. This shift has led to a growing complacence in some quarters, but concern in others, about several underlying features of production and consumption that may make the present position difficult to sustain over the years. This study addresses growth and patterns in India's foodgrain production and consumption along with some of the major factors influencing them. It then examines how production and consumption are likely to change in the future and what the state of foodgrains might be under alternative scenarios of growth and development.

In an earlier IFPRI report, Sarma and Roy (1979) examined the data on production, availability, and consumption of foodgrains in India during the period 1960/61-1976/77.[1] The report raised concerns about an apparent stagnation or decline in the per capita consumption of foodgrains in the country. The performance of Indian agriculture was reviewed in another IFPRI report (Sarma 1981), which concluded that the new strategy of agricultural production based on high-yielding varieties (HYVs) did contribute to the growth in foodgrain production and productivity. But, since this growth was confined largely to wheat and irrigated areas, its overall impact on aggregate foodgrain production growth was limited. Another IFPRI report (Paulino 1986) examined past global trends in production and consumption of major food crops in the developing countries at the overall and country group levels, and projected them to 2000 to identify the emerging gaps between projected output and estimated demand. Trend analysis of food production and consumption was attempted by Paulino and Sarma (1988) at the country level for two major countries, Nigeria and Brazil, in 1986. With this background, the present work attempts a detailed study on foodgrains in India.

In past literature on Indian agricultural performance there were concerns in the early 1980s about a possible deceleration in foodgrain production (Alagh and Sharma 1980; Desai and Namboodiri 1983). Mehra (1981) and Hazell (1982) examined the question of instability in foodgrain production and found that instability had increased after the green revolution. Bhalla and Alagh (1978) studied the growth rates at the district level between 1962-65 and 1970-73; their main finding was that the yield effect was the major component of growth in most of the 48 high-growth districts. Dev (1985) extended this analysis to 1975-78. More recently, Bhalla and Tyagi (1989) have examined growth in agriculture at the district and state levels using averages of 1962/63-1964/65, 1970/71-1972/73, and 1981/82-1983/84. They examined spatial aspects of association between growth and modern input use, and changes in regional concentration.

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[1] In reference to production, area, and yield, the split years such as 1983/84 refer to the crop year from July 1983 to June 1984. The availability data relate to calendar years. The output of agricultural year 1983/84 is treated as available for consumption in calendar year 1984.

Narain (1977) studied the growth rate of productivity by decomposing it and segregating the effects of changes in cropping pattern and the spatial shifts of crops. Although the contribution of new technology to the acceleration of wheat production is well recognized, there has been some controversy over its contribution to overall foodgrain and agricultural production (Mitra 1968; Minhas and Srinivasan 1968; Srinivasan 1972, 1979; Rao 1975; Rudra 1978; Dantwala 1978). Dantwala found that the HYV technology brought about significant improvement in the productivity of cereal crops, but its overall effect on foodgrain production, especially when evaluated in per capita terms, is not significant.

Trends and projections for foodgrains in India have also been made by a number of national and international organizations such as the National Commission on Agriculture, the World Bank, and the Indian Planning Commission. These studies, however, were mainly based on analysis of national aggregate data. A study (IFPRI 1984) that examined Asian Development Bank countries, including India, also falls in this category.

The present study extends IFPRI's trend analysis to policy research for foodgrains in India. It uses national data disaggregated into regions and relevant time periods on the output side and into rural and urban areas and income groups on the demand side. But the primary focus is on policy research based on the following questions: Has the trend in India's foodgrain production decelerated in recent years? What has been the performance of different regions and different crops and how has it changed over time? What has been the contribution of area, yield per hectare, and the cropping pattern on the one hand and inputs such as irrigation, HYVs, fertilizers, and rainfall on the other to the increase in production? Has there been any decline in the productivity of yield-increasing inputs over time? What have been the trends in the consumption of foodgrains over time in rural and urban areas? In light of this analysis, what are the prospects for growth in foodgrain output by 2000, and how does the projected level of production compare with the likely level of consumption in that year? What would be the implications for foodgrains of the objectives of faster economic growth and elimination of poverty envisaged in the Perspective Plan of the Government of India (India, Planning Commission 1985, vol. 1, chap. 2).

The total geographical area of India is about 329 million hectares, of which nearly 47 percent is cultivated. The gross area under foodgrains in 1983/84 was estimated at about 131 million hectares, or nearly three-fourths of the gross cropped area. Foodgrain output in the same year was 152 million metric tons,[2] giving an average yield per hectare of about 1.16 tons.[3] About 31 percent of the area under foodgrains was irrigated, and around 54 million hectares were covered by HYV cereals in 1983/84. The total consumption of chemical fertilizers was 7.7 million tons (NPK), of which 60 percent was endogenously produced. The share of foodgrains in fertilizer use is estimated at about 75 percent. The estimated midyear population of India in 1984 was 736 million, of which about 77 percent were in the rural areas. The total net availability of foodgrains, excluding the allowances for seed, feed, and wastage, and including imports and changes in government stocks, was about 129 million tons, giving a per capita availability of 175 kilograms in that year.

Chapter 3 examines the trends and changes in production of rice, wheat, coarse cereals, pulses, and total foodgrains at the all-India aggregate level and at the regional level.[4] The time span of the analysis, 1949/50-1983/84, is divided into the pre-green-revolution period (1949/50-1964/65) and the green-revolution period (1967/68-1983/84).[5] The second period is subdivided into two subperiods, 1967/68-1975/76 and 1975/76-1983/84. The country is divided into six regions, Northern, Uttar Pradesh, Central, Western, Eastern, and Southern, mainly on the basis of geographical location, agroclimatic conditions, cropping pattern, and approximately equal shares in total foodgrain production.

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[2] All tons in this report are metric tons.

[3] Foodgrains include rice, wheat, maize, sorghum, *bajra*, *ragi*, small millets, barley, gram, and other pulses. The area and output data relate to crop year July to June, divided into *kharif* and *rabi* seasons.

Input productivity and production behavior of foodgrain output are examined in Chapter 4 using response coefficients, factor analysis, and production function analysis. An attempt is made to find the timing and magnitude of the change in input productivities and to separate the effects of fluctuations in rainfall on production by using a specially constructed all-India foodgrain rainfall index.

Chapter 5 examines the changes over time in per capita availability of foodgrains for human consumption, based on data from the Ministry of Agriculture, and in per capita direct consumption, using National Sample Survey data. Changes in the patterns of consumption are also examined. Alternative scenarios of production and consumption in 2000 and the resulting supply-demand balances are discussed in Chapter 6, while Chapter 7 reviews the important conclusions of this study and their policy implications.

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[4] Coarse cereals include maize, sorghum, *bajra*, *ragi*, small millets, and barley. Rice, wheat, and coarse cereals together form the cereals group.

[5] The years 1965/66 and 1966/67 were highly abnormal drought years and hence were not included in this analysis.

# 3

# TRENDS AND CHANGES IN FOODGRAIN PRODUCTION

The past performance of the growth in foodgrain production in India is examined here in the aggregate and with some principal underlying disaggregations into time periods, major crops, area and yield, and six major growing regions. Examination of the overall aggregate time-series data shows that, with some fluctuations, and possibly with changes in contributory factors, the long-term growth of foodgrain production has been sustained at about 2.6 percent a year for over three decades.[6] Analysis indicates that about 30.0 percent of this growth came from area increase and about 70.0 percent from higher yields per hectare. This shows that yield increase has played a major role in the growth of foodgrain production, and policies to sustain yield growth will be crucial for the future.

The initial rapid increase in cropped area continued until the early 1960s (Table 1). Of the total increase in average gross cropped area from 97.3 million hectares in

**Table 1—Area, yield, and production of foodgrains, 1949/50-1983/84**

| | Three-Year Average | | | | |
|---|---|---|---|---|---|
| Item/Period | Rice | Wheat | Coarse Cereals | Pulses | All Food-grains |
| Cropped area (million hectares) | | | | | |
| 1949/50-1951/52 | 30.5 | 9.7 | 38.3 | 18.9 | 97.3 |
| 1962/63-1964/65 | 36.1 | 13.5 | 44.2 | 24.1 | 117.8 |
| 1967/68-1969/70 | 37.0 | 15.9 | 46.9 | 22.0 | 121.8 |
| 1981/82-1983/84 | 39.9 | 23.5 | 41.7 | 23.4 | 128.5 |
| Yield (kilograms/hectare) | | | | | |
| 1949/50-1951/52 | 763 | 688 | 464 | 501 | 587 |
| 1962/63-1964/65 | 1,014 | 812 | 557 | 471 | 708 |
| 1967/68-1969/70 | 1,060 | 1,160 | 577 | 518 | 790 |
| 1981/82-1983/84 | 1,332 | 1,784 | 746 | 517 | 1,076 |
| Production (million metric tons) | | | | | |
| 1949/50-1951/52 | 23.3 | 6.6 | 17.8 | 9.5 | 57.1 |
| 1962/63-1964/65 | 36.6 | 11.0 | 24.6 | 11.3 | 83.5 |
| 1967/68-1969/70 | 39.3 | 18.4 | 27.1 | 11.4 | 96.2 |
| 1981/82-1983/84 | 53.3 | 41.9 | 31.1 | 12.1 | 138.4 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years).

Notes: 1965/66 and 1966/67 were highly abnormal drought years and therefore have been excluded from the analysis. Parts may not add to totals because of rounding.

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[6] In computing this long-term growth rate, the production estimates for the abnormal drought years 1965/66 and 1966/67 were involved. If a dummy is used instead for these years, the resulting change in the output growth rate is marginal, from 2.5643 percent without the dummy to 2.5586 percent with the dummy.

1949/50-1951/52 to 128.5 million hectares in 1981/82-1983/84, two-thirds came during the pre-green-revolution period, that is, up to 1962/63-1964/65. With the green revolution (beginning in 1967/68), the major source of growth became the yield, and almost three-fourths of the overall increase in average yield—from 587 kilograms in 1949/50-1951/52 to 1,076 kilograms per hectare in 1981/82-1983/84—occurred after 1967/68. Thus, over the years there has been a change toward increased importance of yield-based growth.

Based on three-year averages among the crops, wheat played a very important role in raising foodgrain production. The yield or per unit area productivity of wheat at 688 kilograms per hectare was below that of rice at 763 kilograms per hectare (measured as milled rice) in 1949/50-1951/52. However, the productivity of wheat rose more than two and a half times and by 1981/82-1983/84 reached a level (1,784 kilograms per hectare) substantially higher than that of rice (1,332 kilograms per hectare). From the beginning of the green revolution, average yields increased by 55 percent for wheat, 25 percent for rice, and 30 percent for coarse cereals. The average yield of pulses remained relatively stagnant at the all-India level. Thus the yield-based growth of the green-revolution period was substantially due to wheat, with smaller contributions from rice and coarse cereals, and almost no contribution from pulses.

It is important to note that the area under wheat also rose nearly two and a half times from 9.7 million hectares in 1949/50-1951/52 to 23.5 million hectares in 1981/82-1983/84, substantially enhancing its contribution to production. The area under rice, coarse cereals, and pulses increased relatively little, especially after the green revolution. The annual average overall foodgrain production in India increased from 57.1 million tons in 1949/50-1951/52 to 138.4 million tons in 1981/82-1983/84, a fairly impressive increase of 142 percent. About half of this increase, to which rice contributed 40 percent and wheat another 30 percent, came before the green revolution. Between 1967/68-1969/70 and 1981/82-1983/84, wheat contributed 55 percent and rice 33 percent of the increased foodgrain output, which grew at an average rate of 3 million tons a year.

Given the large differences in yield as well as changes in area under different crops, particularly rice, wheat, and coarse grains (coarse cereals plus pulses), it was important to at least broadly investigate which part of the large overall increase in yield came from what can be called the "pure yield effect" (see Narain 1977) and which part came from the "cropping pattern effect." The analysis was carried out for fine grains (wheat and rice) and coarse grains (coarse cereals and pulses), following methodology described in Appendix 1. The results, based on all-India data, show that in the pre-green-revolution period as much as 97 percent of the yield increase came from the pure yield effect, and only about 2 percent came from the cropping pattern effect (Table 2). In the green-revolution period the share of the cropping pattern effect rose to 11 percent, but the share of the pure yield effect remained high at 83 percent. The analysis shows that even though cropping pattern changes can have a large effect on yield increase (and possibly did so in some regions), the all-India yield increase seems to have been driven substantially by pure increases in the individual crop yields. This may in part be because of rigidities on account of basic agroclimatic conditions as well as constraints from consumption patterns that may have limited the cropping pattern changes. The analysis indicates that, within the importance of yield-based growth, input-based pure yield growth for each major crop may be of considerable significance in overall growth of yield and production. This may call for a research and extension focus on each of the major crops.

## Table 2—Decomposition of yield increase into pure yield effect and cropping pattern effect, 1949/50-1983/84

| | Three-Year Averages | | | |
|---|---|---|---|---|
| Category[a] | 1949/50-1951/52 | 1962/63-1964/65 | 1967/68-1969/70 | 1981/82-1983/84 |
| Area (million hectares) | | | | |
| Fine grains | 40.1 | 49.6 | 52.9 | 63.4 |
| Coarse grains | 57.1 | 68.3 | 68.9 | 65.1 |
| All foodgrains | 97.3 | 117.8 | 121.8 | 128.5 |
| Yield (kilograms/hectare) | | | | |
| Fine grains | 745 | 959 | 1,090 | 1,499 |
| Coarse grains | 477 | 526 | 558 | 664 |
| All foodgrains | 587 | 708 | 789 | 1,076 |
| Area share (percent) | | | | |
| Fine grains | 0.4126 | 0.4205 | 0.4342 | 0.493 |
| Coarse grains | 0.5874 | 0.5794 | 0.5658 | 0.506 |
| Change in area share (percent) | | | | |
| Fine grains | . . . | 0.0079 | . . . | 0.059 |
| Coarse grains | . . . | –0.0080 | . . . | –0.592 |
| Change in yield (kilograms/hectare) | | | | |
| Fine grains | . . . | 214 | . . . | 409 |
| Coarse grains | . . . | 50 | . . . | 106 |
| All foodgrains | . . . | 121 | . . . | 287 |
| Pure yield effect (kilograms/hectare) | . . . | 117.45 | . . . | 237.17 |
| Pure yield effect (percent) | . . . | 97.22 | . . . | 82.79 |
| Cropping pattern effect (kilograms/hectare) | . . . | 2.08 | . . . | 31.40 |
| Cropping pattern effect (percent) | . . . | 1.72 | . . . | 10.96 |
| Interaction (kilograms/hectare) | . . . | 1.29 | . . . | 1.07 |
| Interaction (percent) | . . . | 17.91 | . . . | 6.25 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years).
Note: Methodology is discussed in Appendix 1.
[a]Fine grains are rice and wheat. Coarse grains are coarse cereals and pulses.

## All-India Growth in Foodgrain Production

In the recent literature on Indian agricultural performance, there have been serious concerns about a possible deceleration in the growth of foodgrain production in the late 1970s and early 1980s (see Alagh and Sharma [1980], Desai and Namboodiri [1983]). Later data permit a critical reexamination of this issue. For this purpose, the period 1949/50-1983/84 is divided into two periods, 1949/50-1964/65 (before the green revolution) and 1967/68-1983/84 (the green-revolution period)[7], and the latter period is further divided into two equal subperiods: 1967/68-1975/76 and 1975/76-1983/84.

Analysis shows that compared with the pre-green-revolution period, growth rates in foodgrain output in 1967/68-1975/76 were lower, at 1.9 percent a year, but in 1975/76-1983/84 growth accelerated to 2.5 percent a year (Table 3).[8] The drop in the

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[7] The years 1965/66 and 1966/67 were years of abnormal drought and have been omitted from the growth rate calculations in this section.

[8] Computation of reliable growth rates in crop production where seasonal factors cause annual fluctuations is difficult. Depending upon the length of the period covered, its beginning and end points and the computation formula adopted, the rates of growth differ greatly, even after the production data are adjusted for changes in coverage and methods of estimation.

### Table 3—Growth rates in area, yield, and production of foodgrains, 1949/50-1983/84

| Category/Period | Rice | Wheat | Coarse Cereals | Total Cereals | Pulses | All Food-grains |
|---|---|---|---|---|---|---|
| | | | (percent/year) | | | |
| Area | | | | | | |
| 1949/50-1964/65 | 1.34 | 2.69 | 0.89 | 1.30 | 1.87 | 1.41 |
| 1967/68-1975/76 | 0.67 | 3.20 | −1.07 | 0.31 | 0.77 | 0.40 |
| 1975/76-1983/84 | 0.22 | 1.94 | −0.46 | 0.31 | −0.32 | 0.19 |
| 1967/68-1983/84 | 0.62 | 2.71 | −0.83 | 0.39 | 0.42 | 0.39 |
| 1949/50-1983/84 | 0.91 | 2.82 | 0.07 | 0.84 | 0.33 | 0.74 |
| Yield | | | | | | |
| 1949/50-1964/65 | 2.23 | 1.27 | 1.25 | 1.77 | −0.41 | 1.41 |
| 1967/68-1975/76 | 1.21 | 2.18 | 1.35 | 1.90 | −1.27 | 1.50 |
| 1975/76-1983/84 | 1.75 | 3.72 | 1.14 | 2.45 | 0.11 | 2.28 |
| 1967/68-1983/84 | 1.59 | 2.88 | 1.84 | 2.41 | −0.21 | 2.14 |
| 1949/50-1983/84 | 1.52 | 3.12 | 1.40 | 2.04 | −0.13 | 1.81 |
| Production | | | | | | |
| 1949/50-1964/65 | 3.49 | 3.99 | 2.16 | 3.09 | 1.44 | 2.84 |
| 1967/68-1975/76 | 1.89 | 5.47 | 0.27 | 2.22 | −0.51 | 1.91 |
| 1975/76-1983/84 | 1.97 | 5.72 | 0.68 | 2.77 | −0.22 | 2.48 |
| 1967/68-1983/84 | 2.23 | 5.67 | 1.00 | 2.80 | 0.21 | 2.54 |
| 1949/50-1983/84 | 2.45 | 6.02 | 1.46 | 2.90 | 0.20 | 2.56 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years).

Note: 1965/66 and 1966/67 were abnormally severe drought years and therefore have been excluded from the subperiods.

output growth rate in 1967/68-1975/76 can be largely attributed to a drop in the area growth rate, but in 1975/76-1983/84 the growth in yield per hectare accelerated from 1.5 percent to 2.3 percent, thereby compensating for the declining growth in area under foodgrains. Thus, contrary to the concerns about deceleration, there appears to have been some acceleration in foodgrain production from the first to the second half of the green-revolution period. More recent preliminary data show that for the succeeding three years, foodgrain production broadly hovered around the 1983/84 level of 152.4 million tons.

The difference in production growth rates between 1967/68-1975/76 and 1975/76-1983/84 when tested by a Chow F-test is not statistically significant. In this connection, Mellor (1988) has noted that there are insurmountable statistical problems in detecting and substantiating small changes in the rates of growth of agricultural production. Year-to-year weather-induced fluctuations in production are very large relative to the economically significant changes in the trend that are important to detect. Choosing a period with a few more good or bad years at either end in a time series can substantially alter the results. This is illustrated in a table (Mellor 1988, 66) on which Mellor notes that an alternative would be to compute rates of growth across peaks and troughs in production that are selected for equivalency in weather variables. For instance, on this basis Mellor finds a growth rate as high as 3.0 percent between the excellent years of 1971/72 and 1983/84. Using this approach, he states that the foodgrain production growth rate in India may have accelerated between the mid-1970s and mid-1980s from somewhat under 2.8 percent to about 3.0 percent. The findings in the present study substantiate this acceleration using time-series growth rates.

The analysis here also shows that there are large differences in the growth rates across different crops (Table 3). Between 1967/68 and 1983/84, wheat output grew at a rate of 5.7 percent a year, which is more than double the overall growth rate in foodgrain output. Both area and yield per hectare contributed almost equally to this growth. The pre-green-revolution growth rate in wheat was around 4.0 percent, to which area contributed about two-thirds. The growth in rice output was 3.5 percent before the green revolution and in 1967/68-1983/84 was 2.2 percent, of which 70 percent was contributed by yield growth. The output of coarse cereals was rising more slowly. There was a decline in the area under coarse cereals in the green-revolution period, but this was more than compensated for by the yield increase. Pulse production continued to be stagnant. The overall rate of increase in area under foodgrains between 1967/68 and 1983/84 was less than 0.4 percent a year, which may continue into the future. This implies that future increases in production will need to come largely from yield increases.

The long-term (1949/50-1983/84) growth rate in foodgrain production came to more than 2.6 percent, to which wheat contributed a large share with a production growth rate of more than 6.0 percent, followed by rice at about 2.5 percent. About half of the growth in wheat production came from its area growth. Given the slow growth in overall foodgrain area, this indicates an increasing share for wheat, mainly through substitution away from coarse cereals to wheat. Production of coarse cereals grew more slowly at about 1.5 percent, primarily due to yield growth, whereas pulses showed a growth rate of only 0.2 percent with a negative yield growth rate. Slow growth in these crops, particularly when demand patterns cannot change, begins to be reflected in their relative prices, and this is increasingly apparent for pulses. Coarse cereals may follow suit if feedgrain demand increases. Poor growth in coarse cereals also affects agricultural growth in dryland regions, where they continue to be the principal crops.

## Regional Growth in Foodgrain Production

India has substantial regional heterogeneity in many aspects such as agroclimatic conditions, resource endowments, development, and cropping patterns. Agriculture therefore varies significantly across different parts of the country. This diversity makes it meaningful to divide the country into regions for examination of production performance. Such division also makes possible a study of underlying regional performance over time, comparison of production growth across regions, and crop performance within and across regions, all of which can help address important issues pertaining to the extent and nature of regional concentration of growth and its persistence.

### Division into Regions

The 31 states and union territories of the country have been grouped into six broad regions: Northern, Uttar Pradesh, Central, Western, Eastern, and Southern. The criteria adopted for this grouping were geographic location, agroclimatic conditions, cropping pattern, and division of the total foodgrain production into somewhat equal parts. The composition and important characteristics of the regions are shown in Tables 4 and 5.

The Northern region, consisting of the far northern states and territories, contributed about 16 percent of the all-India foodgrain production in 1980/81 with a share of only 8 percent in foodgrain area, giving it a relatively high average yield of 1.9 tons per hectare. Wheat predominates among foodgrains in the region, with a 58 percent share of foodgrain production.

## Table 4—Composition of regions and regional shares of foodgrain production, 1980/81

| Region | States and Union Territories | Share of Population | Share of Foodgrain Production | Relative Share of Crops in Foodgrain Production: Wheat | Rice | Coarse Cereals and Pulses | Total |
|---|---|---|---|---|---|---|---|
| | | | | (percent) | | | |
| Northern | Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Delhi, Chandigarh | 6.8 | 15.9 | 58 | 25 | 17 | 100 |
| Uttar Pradesh | Uttar Pradesh | 16.2 | 19.2 | 54 | 22 | 24 | 100 |
| Central | Madhya Pradesh, Rajasthan | 12.6 | 14.6 | 29 | 22 | 48 | 100 |
| Western | Maharashtra, Karnataka, Gujarat, Goa, Daman and Diu, Dadra and Nagar Haveli | 19.7 | 15.7 | 12 | 26 | 62 | 100 |
| Eastern | Bihar, West Bengal, Orissa, Assam, Tripura, Manipur, Meghalaya, Arunachal Pradesh, Nagaland, Sikkim, Mizoram, Andaman and Nicobar Islands | 26.0 | 21.7 | 11 | 75 | 14 | 100 |
| Southern | Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry, Lakshadweep | 18.7 | 13.0 | . . . | 74 | 26 | 100 |
| All India | . . . | 100.0 | 100.0 | 28 | 41 | 31 | 100 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Indian Agriculture in Brief,* various issues (Delhi: Controller of Publications, various years).

Note: Parts may not add to totals because of rounding.

## Table 5—Regional foodgrain yields and shares of area and major inputs, 1980/81

| Region | Yield per Hectare of Foodgrains | Gross Cropped Area | Area Under Foodgrains | Area Under High-Yielding Varieties | Fertilizer Consumption | Irrigated Area |
|---|---|---|---|---|---|---|
| | (kilograms) | | | (percent) | | |
| Northern | 1,940 | 7.8 | 8.4 | 16.2 | 19.1 | 19.6 |
| Uttar Pradesh | 1,219 | 16.0 | 16.2 | 20.5 | 21.3 | 22.9 |
| Central | 627 | 22.1 | 23.8 | 11.7 | 6.2 | 12.5 |
| Western | 803 | 23.0 | 19.9 | 19.2 | 20.9 | 13.2 |
| Eastern | 1,061 | 19.0 | 20.9 | 17.9 | 10.8 | 15.6 |
| Southern | 1,227 | 12.1 | 10.9 | 14.5 | 21.8 | 16.2 |
| | (kilograms) | | (million hectares) | | (million metric tons) | (million hectares) |
| All India | 1,023 | 162.2 | 126.7 | 43.1 | 5.5 | 49.6 |

Sources: For area and yield, India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); and for fertilizers, high-yielding varieties, and irrigation, Fertilizer Association of India, *Fertilizer Statistics* (New Delhi: FAI, 1985 and 1986).

The state of Uttar Pradesh, which because of its size and total production is here considered a region by itself, contributed almost 20 percent of India's foodgrain production with a 16 percent share in area. Its crop production pattern is similar to that of the Northern region, with wheat holding a 54 percent share in the foodgrain output of Uttar Pradesh. Coarse cereals and pulses are somewhat more important and rice somewhat less important here than in the Northern region.

The Central region comprises the states of Madhya Pradesh and Rajasthan and produced about 15 percent of the country's foodgrains with a 24 percent share in the area. Coarse grains and pulses are much more important in this region than in the Northern and Uttar Pradesh regions, but wheat is also fairly important with a share of 29 percent. The average foodgrain yield is relatively low at 627 kilograms per hectare.

The Western region contributed about 16 percent of India's foodgrains with a share of 20 percent in area. Coarse grains and pulses predominate and together hold a share of more than 60 percent in the region's production. The average foodgrain yields are low, at 803 kilograms per hectare, because of the predominant share of coarse grains and pulses. Wheat is not important but rice holds a significant share.

The Eastern region, composed of all the eastern states, had a 22 percent share in the country's foodgrain production. It is predominantly a rice-growing area, with that crop holding a 75 percent share of the region's foodgrain production. The remaining 25 percent is distributed among wheat and other foodgrains. The average foodgrain yield per hectare is about 1,060 kilograms.

The Southern region contributes 13 percent of the national output of foodgrains and is predominantly a rice-producing area but has almost no wheat. Coarse grains and pulses have a 26 percent share in the region's production. Rice yields here are the second highest among the regions at 1,880 kilograms per hectare, and the overall foodgrain yield of 1,227 kilograms per hectare is also the second highest after that of the Northern region.

The distribution of input use is also unequal among the regions (Table 5). The Uttar Pradesh region had the largest share in gross irrigated area and in area under HYVs, while the Southern region accounted for the largest share in consumption of fertilizers in 1980/81. The Central region had the smallest shares in each of these three inputs. Uttar Pradesh, with 23 percent, is followed closely by the Northern region in the share of gross irrigated area. Barring the Central and Uttar Pradesh regions, the share of the other four regions varied from 15 to 19 percent in total area under HYVs. Of the total consumption of 5.5 million tons of chemical fertilizers (NPK), four of the six regions used 19-21 percent each. The share of the Eastern region was only about 10 percent despite a large share in area. On a per hectare basis, fertilizer consumption in the Northern region was more than double that of the national average.

Assembling consistent and comparable data for the regional study of production posed many problems. First, it involved putting together data from the present 31 states and union territories over some 30 years. Many new states have been created during this period, and the boundaries of many states have been redefined, resulting in changes in the distribution of cropped area. The system of crop reporting has been extended to new areas, thus bringing in an element of noncomparability in the reported estimates over time. Traditional methods of yield estimation based on eye estimates of the condition of the crop have been gradually replaced by systematic and objective crop-cutting techniques, state by state. The effects of all these changes pose great problems for time-series data analysis and valid regional comparisons. Appendix 2 describes the way in which these problems were overcome. On this basis, largely consistent and comparable time-series statistics for cropped area, yield, and production could be assembled for rice, wheat, coarse cereals, total cereals, pulses, and total foodgrains from 1952/53 to 1983/84 for the six regions of the country.

### Comparison of Regional Growth Performance

The time span from 1952/53 to 1983/84 is divided into three appropriate subperiods: 1952/53-1964/65 is considered the pre-green-revolution period, 1967/68-1975/76 the first part of the green-revolution period, and 1975/76-1983/84 the second part of the green-revolution period. The years 1965/66 and 1966/67 were excluded from the growth rate analysis because they were highly abnormal, severe, and consecutive drought years, which would strongly affect growth rate estimates and their comparability.

Semilogarithmic trend equations were fitted to the annual time-series data to obtain compound growth rates. The growth rate estimates are given in Table 6, and a few salient growth rates are illustrated in Figures 1 and 2. The growth rate t-statistics are in Appendix 3. Some broad figures on input levels in the six regions at three appropriate time points in the green-revolution period are provided in Table 7. These may help in observing some possible associations behind differences and changes in these growth rates. The growth rate results indicate striking differences in growth across regions and over time.

### Overall Foodgrain Growth Rates

In the Northern region, production of foodgrains has been growing at a rapid rate of 3.5-5.0 percent throughout the postindependence period. The overall foodgrain growth rates (Table 6) show that the contribution of area to this growth gradually declined in the 1952/53-1983/84 period, whereas the contribution of yield substantially increased. From 1967/68-1975/76 to 1975/76-1983/84 there was a large acceleration in the production growth rate, from 3.3 percent to 5.1 percent. This came mainly from an increase in yield growth rate, from 2.0 percent to 4.2 percent, which was substantially spurred by an increase in the yield growth rate of wheat as well as rapid area growth in both rice and wheat—apparently at the expense of other cereals and pulses. This indicates that the cropping pattern effect made an important contribution to yield growth in this region. The input data in Table 7 show that all inputs have contributed to this growth, but rapid increase in fertilizer use during 1975/76-1983/84 may have influenced the acceleration in production growth.

In this respect the Uttar Pradesh region shows a dramatic change. Its production growth rate was the lowest among the six regions in both the pre-green-revolution period (0.79 percent) and the first half of the green-revolution period (0.52 percent). From this it jumped to 4.8 percent in the second half of the green-revolution period. This is an enormous change for the region and very significant for India, since Uttar Pradesh has a large share in the country's foodgrain production and area. Eighty percent of this high growth rate is attributable to yield growth, since foodgrain area rose at only around 1 percent a year. Table 7 shows that a large contribution to this increase may have come from fertilizers—the annual rate of increase in fertilizer use quadrupled in this period, whereas the rates of increase in irrigation and HYVs did not show a large change.

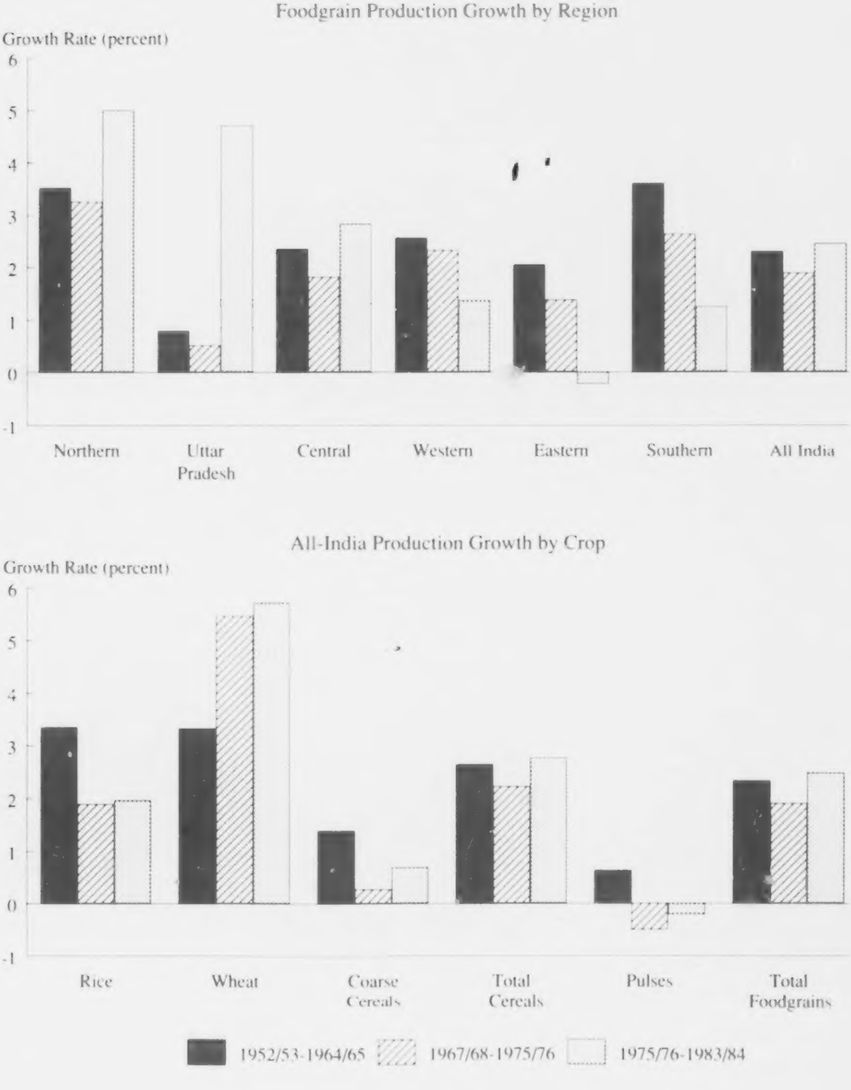
A positive change also took place in the Central region, where the growth in output of foodgrains increased from 1.8 percent to 2.9 percent between the first and the second parts of the green-revolution period. Both area and yield increases contributed to this growth. Input data show that these could have come from significant increases in irrigation and fertilizer use.

## Table 6—Regional growth rates of area, production, and yield of foodgrains, 1952/53-1983/84

| Region/Period | Rice | | | Wheat | | | Coarse Cereals | | | Total Cereals | | | Total Pulses | | | Total Foodgrains | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| | (percent/year) | | | | | | | | | | | | | | | | | |
| Northern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 4.64 | 5.99 | 1.29 | 3.30 | 5.25 | 1.89 | -0.17 | 2.45 | 2.62 | 1.84 | 4.39 | 2.52 | 1.37 | 1.23 | -0.14 | 1.64 | 3.58 | 1.91 |
| 1967/68-1975/76 | 4.54 | 10.24 | 5.45 | 2.75 | 4.49 | 1.69 | 0.21 | 0.85 | 0.65 | 1.98 | 4.38 | 2.36 | -1.98 | -5.77 | -3.85 | 1.26 | 3.30 | 2.02 |
| 1975/76-1983/84 | 8.38 | 11.36 | 2.75 | 3.20 | 6.36 | 3.07 | -3.69 | -2.03 | 1.73 | 2.16 | 6.19 | 3.95 | -7.55 | -14.42 | -7.43 | 0.89 | 5.13 | 4.21 |
| Uttar Pradesh | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.83 | 4.29 | 2.42 | 0.84 | 1.54 | 0.70 | -0.93 | -0.61 | 0.33 | 0.38 | 1.46 | 1.08 | 0.53 | -1.20 | -1.72 | 0.42 | 0.79 | 0.37 |
| 1967/68-1975/76 | 0.22 | 2.90 | 2.66 | 2.86 | 3.14 | 0.27 | -1.87 | -1.74 | 0.13 | 0.44 | 1.69 | 1.25 | -3.51 | -5.36 | -1.92 | -0.32 | 0.52 | 0.84 |
| 1975/76-1983/84 | 1.81 | 4.83 | 2.97 | 3.83 | 8.34 | 4.33 | -3.23 | -1.97 | 1.30 | 1.36 | 5.51 | 4.09 | -0.95 | -0.70 | 0.24 | 1.01 | 4.81 | 3.77 |
| Central | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.30 | 2.17 | 0.86 | 3.49 | 2.74 | -0.73 | 1.30 | 2.27 | 0.95 | 1.72 | 2.34 | 0.60 | 2.08 | 2.62 | 0.53 | 1.82 | 2.38 | 0.56 |
| 1967/68-1975/76 | 1.12 | 0.57 | -0.54 | 2.08 | 5.02 | 2.88 | -1.34 | -0.72 | 0.63 | -0.05 | 1.26 | 1.34 | 2.61 | 4.09 | 1.43 | 0.66 | 1.84 | 1.17 |
| 1975/76-1983/84 | 0.73 | 1.85 | 1.11 | 1.24 | 5.62 | 4.34 | 1.94 | 3.16 | 1.20 | 1.49 | 3.74 | 2.21 | -0.77 | -0.48 | 0.30 | 0.83 | 2.87 | 2.02 |
| Western | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.87 | 4.29 | 2.38 | 1.19 | 3.48 | 2.28 | 0.01 | 2.41 | 2.41 | 0.34 | 2.98 | 2.63 | -0.34 | -0.27 | 0.07 | 0.22 | 2.59 | 2.37 |
| 1967/68-1975/76 | -0.43 | 1.38 | 1.82 | 1.75 | 8.24 | 6.39 | -1.20 | 1.57 | 2.82 | -0.84 | 2.22 | 3.09 | 1.86 | 3.56 | 1.68 | -0.39 | 2.36 | 2.76 |
| 1975/76-1983/84 | 0.78 | 1.42 | 0.63 | -1.02 | 1.13 | 2.17 | 0.04 | 1.19 | 1.15 | 0.04 | 1.23 | 1.19 | 1.59 | 2.87 | 1.26 | 0.32 | 1.38 | 1.05 |
| Eastern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 0.69 | 2.19 | 1.49 | 0.71 | 2.23 | 1.51 | 0.72 | 2.21 | 1.48 | 0.70 | 2.20 | 1.49 | 0.57 | 1.10 | 0.52 | 0.68 | 2.07 | 1.38 |
| 1967/68-1975/76 | 0.72 | 0.64 | -0.08 | 9.61 | 15.11 | 5.01 | -0.11 | -2.26 | -2.16 | 1.33 | 1.73 | 0.41 | 0.60 | -2.66 | -3.24 | 1.23 | 1.39 | 0.15 |
| 1975/76-1983/84 | -0.73 | -0.58 | 0.15 | -1.87 | -0.89 | 1.02 | -1.32 | 0.99 | 2.35 | -0.91 | -0.48 | 0.43 | 0.42 | 3.19 | 2.75 | -0.74 | -0.22 | 0.52 |
| Southern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 2.62 | 4.64 | 1.96 | 1.61 | 1.15 | -0.46 | -0.60 | 2.12 | 2.74 | 0.87 | 3.82 | 2.92 | 0.28 | -0.18 | -0.46 | 0.79 | 3.67 | 2.84 |
| 1967/68-1975/76 | 0.46 | 2.88 | 2.40 | 9.24 | 28.94 | 18.02 | -0.58 | 1.62 | 2.21 | -0.03 | 2.56 | 2.58 | 1.79 | 6.07 | 4.21 | 0.20 | 2.66 | 2.46 |
| 1975/76-1983/84 | -0.68 | 1.93 | 2.63 | -4.90 | -4.64 | 0.27 | -2.98 | -1.29 | 1.76 | -1.72 | 1.12 | 2.89 | 1.55 | 5.24 | 3.63 | -1.28 | 1.27 | 2.58 |
| All India | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.57 | 3.34 | 1.74 | 2.29 | 3.32 | 1.02 | 0.21 | 1.38 | 1.16 | 0.99 | 2.63 | 1.62 | 1.36 | 0.62 | -0.73 | 1.07 | 2.33 | 1.25 |
| 1967/68-1975/76 | 0.67 | 1.89 | 1.21 | 3.20 | 5.47 | 2.18 | -1.07 | 0.27 | 1.35 | 0.31 | 2.22 | 1.90 | 0.77 | -0.51 | -1.27 | 0.40 | 1.91 | 1.50 |
| 1975/76-1983/84 | 0.22 | 1.97 | 1.75 | 1.94 | 5.72 | 3.72 | -0.46 | 0.68 | 1.14 | 0.31 | 2.77 | 2.45 | -0.32 | -0.22 | 0.11 | 0.19 | 2.48 | 2.28 |

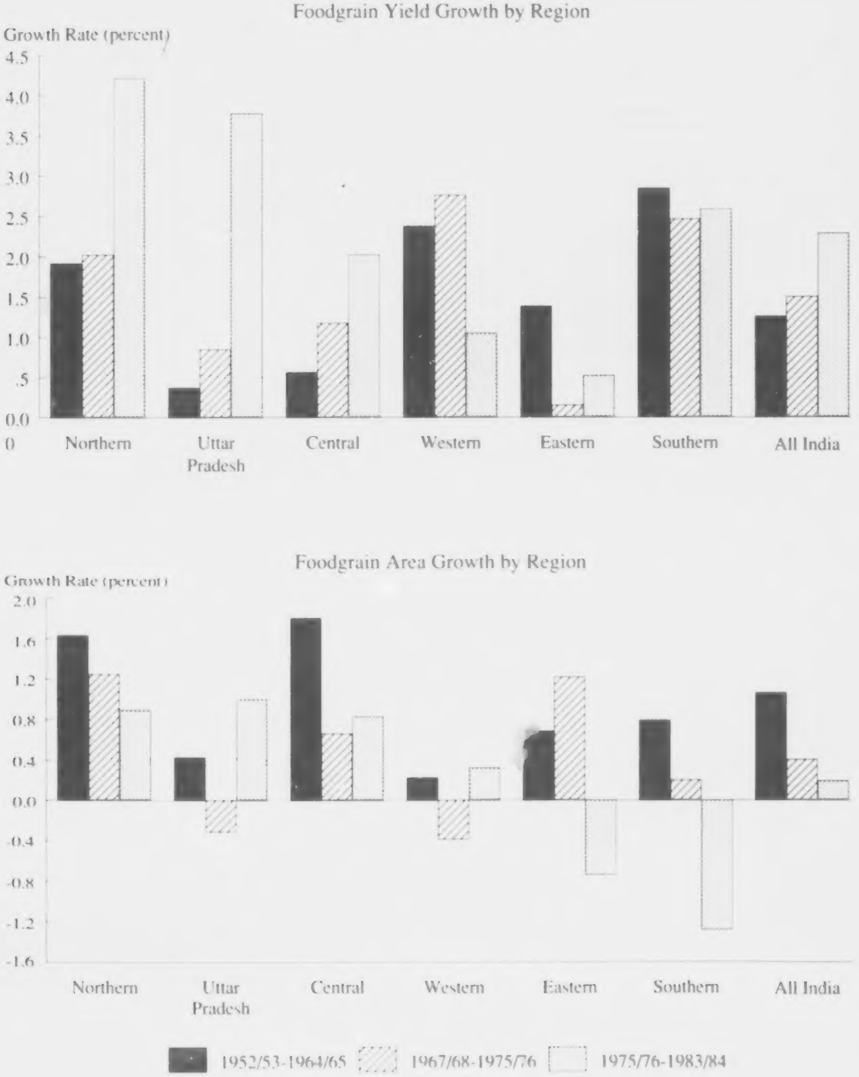
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

**Figure 1—Regional and all-India growth rates in foodgrain production, 1952/53-1983/84**



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 2—Regional and all-India growth rates in foodgrain yield and area, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

**Table 7—Gross irrigated area, total fertilizer consumption, and total area under high-yielding varieties, 1967/68-1983/84**

| Region/Input | 1967/68 | 1975/76 | 1983/84 | Annual Increase, 1967/68-1975/76 | Annual Increase, 1975/76-1983/84 |
|---|---|---|---|---|---|
| Northern | | | | | |
| Irrigation (1,000 hectares) | 5,727 | 7,944 | 10,495 | 277 | 319 |
| Fertilizer (1,000 metric tons) | 146 | 434 | 1,362 | 36 | 116 |
| High-yielding varieties (1,000 hectares) | 929 | 5,095 | 8,278 | 521 | 398 |
| Uttar Pradesh | | | | | |
| Irrigation (1,000 hectares) | 6,352 | 9,231 | 12,148 | 360 | 365 |
| Fertilizer (1,000 metric tons) | 196 | 485 | 1,643 | 36 | 145 |
| High-yielding varieties (1,000 hectares) | 1,848 | 6,332 | 10,145 | 560 | 477 |
| Central | | | | | |
| Irrigation (1,000 hectares) | 3,303 | 4,830 | 6,881 | 191 | 256 |
| Fertilizer (1,000 metric tons) | 47 | 186 | 525 | 17 | 42 |
| High-yielding varieties (1,000 hectares) | 287 | 3,485 | 6,962 | 400 | 435 |
| Western | | | | | |
| Irrigation (1,000 hectares) | 3,765 | 5,422 | 7,259 | 207 | 230 |
| Fertilizer (1,000 metric tons) | 323 | 639 | 1,637 | 40 | 125 |
| High-yielding varieties (1,000 hectares) | 1,188 | 6,424 | 11,000 | 655 | 572 |
| Eastern | | | | | |
| Irrigation (1,000 hectares) | 5,817 | 7,178 | 8,408 | 170 | 154 |
| Fertilizer (1,000 metric tons) | 104 | 322 | 795 | 27 | 59 |
| High-yielding varieties (1,000 hectares) | 830 | 5,105 | 9,901 | 534 | 599 |
| Southern | | | | | |
| Irrigation (1,000 hectares) | 8,057 | 8,339 | 8,740 | 35 | 50 |
| Fertilizer (1,000 metric tons) | 341 | 782 | 1,638 | 55 | 107 |
| High-yielding varieties (1,000 hectares) | 972 | 5,309 | 7,299 | 542 | 249 |
| Other | | | | | |
| Irrigation (1,000 hectares) | 2 | . . . | 6 | . . . | . . . |
| Fertilizer (1,000 metric tons) | 10 | 46 | 111 | . . . | . . . |
| High-yielding varieties (1,000 hectares) | . . . | 126 | 154 | . . . | . . . |
| All India | | | | | |
| Irrigation (1,000 hectares) | 33,023 | 42,944 | 53,937 | 1,240 | 1,374 |
| Fertilizer (1,000 metric tons) | 1,166 | 2,894 | 7,711 | 216 | 602 |
| High-yielding varieties (1,000 hectares) | 6,055 | 31,877 | 53,739 | 3,228 | 2,733 |

Sources: Based on data from Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years).

The Western region, however, showed a slowdown in the growth rate of production from 2.4 percent to 1.4 percent, or by nearly half between the first and second parts of the green-revolution period. Of even more concern is a drop from 2.8 percent to 1.1 percent in the yield growth rate in this region. Input data do not explain this decline, particularly since the annual rate of increase of total fertilizer use actually tripled in the last period. Since this decline in production growth is very large and the region is significant in its size, population, and contribution to the total foodgrain production, the issue is further examined below.

To study this decline, the Western region was disaggregated into its three major states: Gujarat, Karnataka, and Maharashtra (Table 8). The individual growth rates indicate that Gujarat apparently did not contribute to the decline. Its production growth in fact accelerated from 1.1 percent to 3.0 percent between the first and second parts of the green-revolution period, and even the yield growth shows slight acceleration. However, Gujarat has only about a 20 percent share in the region's production. The major impact appears to have come from Karnataka, whose production growth rate declined from about 4.0 percent to 1.0 percent and yield growth rate from 4.8 percent to −0.3 percent. Even Maharashtra's production growth rate declined from 1.4 percent to 1.0 percent, and this had a sizable effect given Maharashtra's share of 50 percent in the region. Since the Western region's production is substantially rainfed, an investigation was made into whether the decline was related to poor rainfall. For this purpose, broad state rainfall indices were computed using available zonal rainfall data (the procedure is discussed in Chapter 4). Karnataka's production showed a close association with the rainfall index, and it appears that Karnataka's production was indeed affected by poor rainfall. Maharashtra's rainfall index also showed a negative trend in this period until 1982/83, and this was probably responsible for dampening production growth in the state. The above analysis indicates that the Western region's production performance in the second half of the green-revolution period was actually heterogeneous among states but may have been substantially affected by poor rainfall in two of them, indicating the vulnerability of this region's production to the rainfall situation.

Foodgrain production in the Eastern region historically has been somewhat slow-growing (Table 6). The rate of growth dropped from 2.1 percent to 1.4 percent between 1952/53-1964/65 and 1967/68-1975/76, and in 1975/76-1983/84 the output actually declined, though mainly because of a decline in the area under foodgrains. There was a slight upturn in the yield growth rate from 0.2 percent to 0.5 percent between these two periods, possibly related to a doubling of the annual increase in fertilizer use. The adoption of HYVs was also proceeding at a brisk pace (Table 7). These changes indicate that growth performance in this region may improve in the future.

In the Southern region, the growth rate in foodgrain output was rapid before the green revolution at 3.7 percent a year. This declined to 2.7 percent between 1967/68 and 1975/76 and further to 1.3 percent in 1975/76-1983/84. However, during 1975/76-1983/84, yield per hectare continued to grow at around 2.6 percent a year. This may be related to a doubling of the rate of annual increase in fertilizer use as well as an increase in the rate of spread of irrigation. The rate of growth in foodgrain area, however, declined from 0.8 percent a year during 1952/53-1964/65 to 0.2 percent during 1967/68-1975/76 and became negative (at −1.3 percent) in the second part of the

**Table 8—Growth rates of foodgrain area, production, and yield in states of the Western region, 1952/53-1983/84**

| State/Period | Total Foodgrains<br>Area | <br>Production | <br>Yield |
|---|---|---|---|
| | | (percent/year) | |
| Gujarat | | | |
| 1952/53-1964/65 | −1.34 | 2.15 | 3.54 |
| 1967/68-1975/76 | −1.50 | 1.12 | 2.65 |
| 1975/76-1983/84 | 0.00 | 2.98 | 2.98 |
| Karnataka | | | |
| 1952/53-1964/65 | 1.03 | 3.53 | 2.48 |
| 1967/68-1975/76 | −0.80 | 3.96 | 4.79 |
| 1975/76-1983/84 | 1.28 | 1.01 | −0.27 |
| Maharashtra | | | |
| 1952/53-1964/65 | 0.36 | 2.09 | 1.72 |
| 1967/68-1975/76 | 0.17 | 1.44 | 1.27 |
| 1975/76-1983/84 | −0.02 | 0.97 | 0.99 |
| Western region | | | |
| 1952/53-1964/65 | 0.22 | 2.59 | 2.37 |
| 1967/68-1975/76 | −0.39 | 2.36 | 2.76 |
| 1975/76-1983/84 | 0.32 | 1.38 | 1.05 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

green-revolution period. Since the total area is not showing a decline, this indicates a movement away from foodgrains in the Southern region.

## Crop Trends within Regions

Estimates of growth rates by crop and region (Figures 3, 4, and 5) show that in the Northern region, growth in foodgrain production came primarily from growth in rice and wheat. More than one-fourth of the foodgrain production was rice, which rose at a surprising rate exceeding 10 percent a year during the entire green-revolution period. However, a large part of this growth came from area, which rose at 8.4 percent in the 1975/76-1983/84 period. Wheat production during this period also grew rapidly at 6.4 percent a year, about half of which came from area. Coarse cereals production has stagnated since the green revolution, and in 1975/76-1983/84 there was a significant shift out of coarse cereals, as shown by an area growth rate of −3.7 percent, though yields still rose at 1.7 percent a year. There was a substantial movement out of pulses, which is reflected in growth rates of −7.6 and −14.4 percent in area and production, respectively, in 1975/76-1983/84.

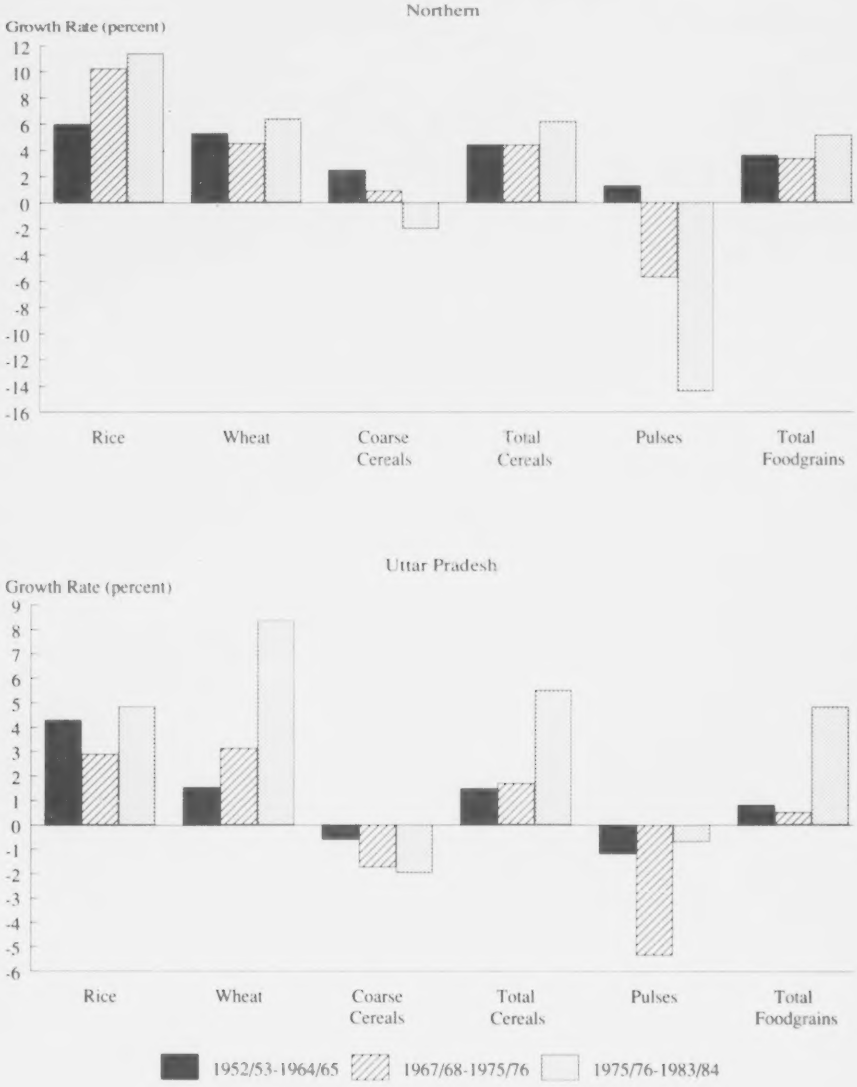
In the Uttar Pradesh region, the rapid increase in the growth rate in 1975/76-1983/84 was fueled mainly by wheat and rice, whose production grew at 8.3 and 4.8 percent, respectively, but unlike that of the Northern region, the bulk of this increase was from yield growth. Like the Northern region, Uttar Pradesh was moving out of coarse cereals and pulses, but in the case of pulses the rate of decline in area was slower, especially during 1975/76-1983/84.

The Central region had a more evenly distributed growth over all the cereals, but wheat continued to be the fastest-growing crop with an annual production growth rate in 1975/76-1983/84 of 5.6 percent, most of which was due to yield growth. Growth in rice production accelerated in the same period. The output of pulses stagnated, however, showing a marginal decline of 0.5 percent a year. Of all the regions, Central had the most rapid growth rate in coarse cereals (3.2 percent a year).

A significant decrease in the growth rate of foodgrain production occurred in the Western region in 1975/76-1983/84, associated with a sharp decline in the growth of wheat in area, production, and yield. Though the share of wheat is not very large in this region (12.0 percent), in the first part of the green-revolution period there was a significant movement into wheat that was reflected in high area and production growth rates (1.8 percent and 8.2 percent, respectively). But in the second part of the green-revolution period there may have been a disillusionment with wheat, as manifested in negative growth in area and much-reduced growth in yield and, consequently, in production. There was also a considerable slowdown in the yield growth rates of rice (from 1.8 percent to 0.6 percent) and coarse cereals (from 2.8 percent to 1.2 percent) and increasing production of pulses (with a growth rate of 2.9 percent), which have lower quantity yields. Pulses have the fastest-rising growth rate of all crops in this region, perhaps indicating a response to the much-improved price environment for pulses.

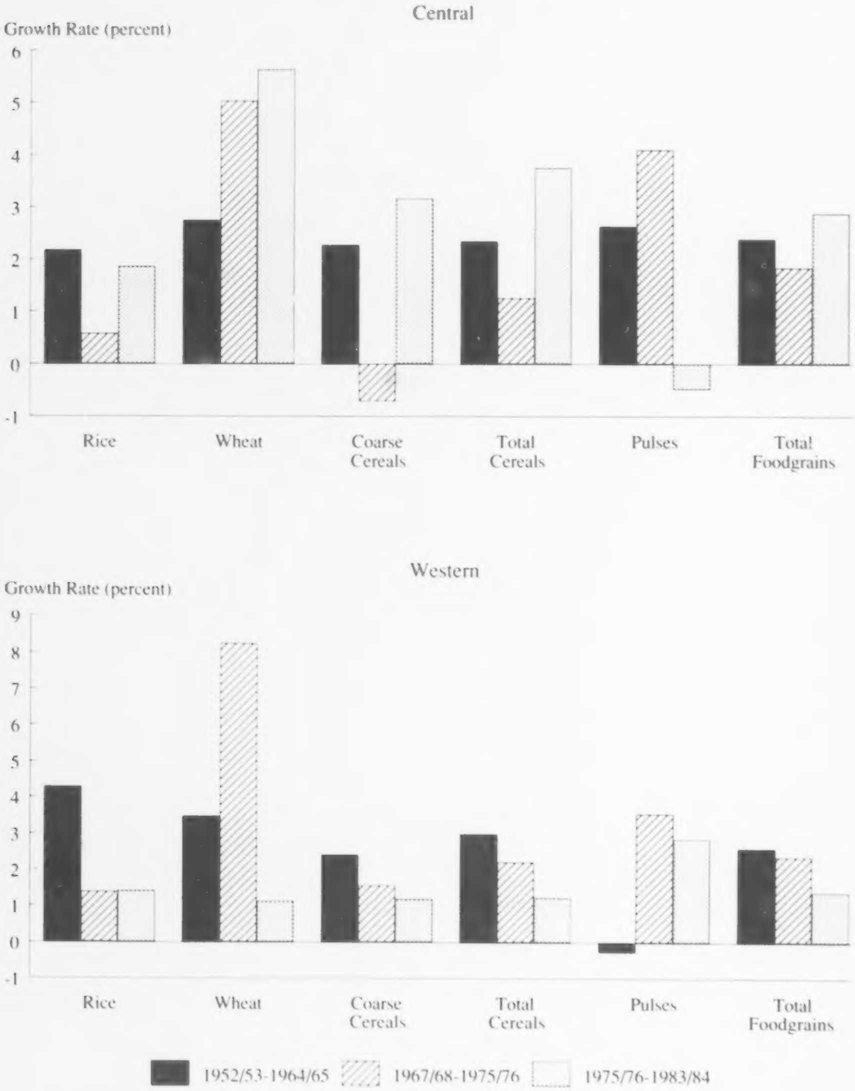
The Eastern region presents a dismal picture, with a decline in growth rate of foodgrain production from 2.1 percent in the pre-green-revolution period to −0.2 percent in 1975/76-1983/84. The only major changes were in wheat and pulses. Wheat has an 11 percent share in the region's foodgrain production. Immediately following the onset of the green revolution there was a great movement into wheat, as shown by the high growth rates of area, yield, and production. However, as in the Western region, during 1975/76-1983/84 there was a change for the worse, with area, yield, and production registering sharp declines in growth rates and even actual decreases. Pulses,

**Figure 3—Annual growth rates in foodgrain production in Northern and Uttar Pradesh regions, by crop, 1952/53-1983/84**



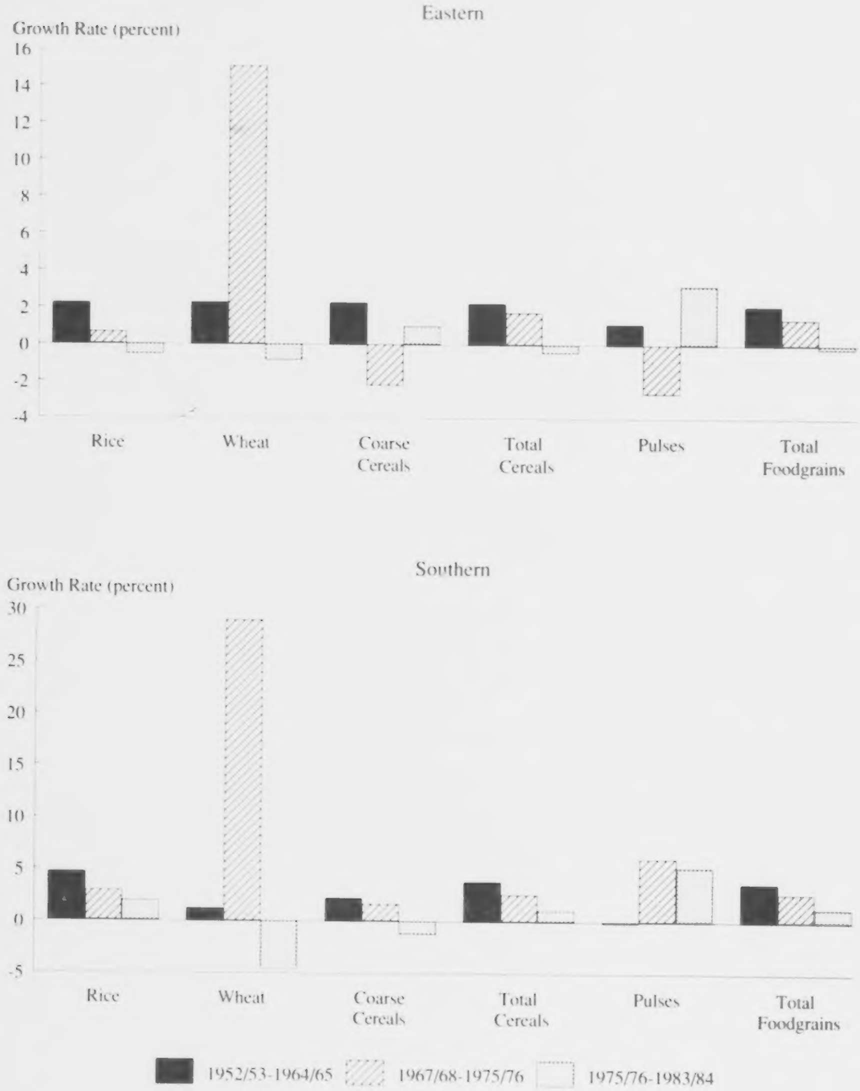
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 4—Annual growth rates in foodgrain production in Central and Western regions, by crop, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

## Figure 5—Annual growth rates in foodgrain production in Eastern and Southern regions, by crop, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

on the other hand, showed a comeback, with relatively high growth rates in yield and production (3.2 percent and 2.8 percent, respectively), perhaps reflecting in part the much-improved national price environment for pulses.

The Southern region continued to show moderate growth in foodgrain production, but the area under foodgrains declined at about 1.3 percent a year in the second part of the green-revolution period, showing a movement out of foodgrains. The decline in area came largely from wheat (−4.9 percent) and coarse cereals (−3.0 percent a year). But the area under pulses increased at 1.6 percent a year. Pulse yield and production rose at annual rates higher than those of any other region, 3.6 percent and 5.2 percent, respectively. This again reflects the effects of much higher relative prices for pulses.

Thus, to recapitulate the regional patterns in the growth of individual crops, wheat and rice production rose most rapidly in the Northern, Uttar Pradesh, and Central regions, but in the Western, Eastern, and Southern regions there was a turn toward pulse production that was reflected in increased area and yields. Whereas coarse cereals declined in almost every other region, their production rose rapidly in the Central region in terms of both area and yield. On an all-India basis, wheat continued to be the fastest-growing foodgrain crop (5.7 percent) in 1975/76-1983/84, followed after a large margin by rice (2.0 percent) and then by coarse cereals (0.7 percent). The all-India output of pulses continued to decline at a rate of −0.2 percent a year. The yield growth rate of rice rose from 1.2 percent to 1.8 percent from the first to the second part of the green-revolution period, and it increased from 2.2 percent to 3.7 percent for wheat. The yield growth rate for coarse cereals declined from 1.4 percent to 1.1 percent, but in the case of pulses the declining trend appears to have been arrested during 1975/76-1983/84. In the green-revolution period the growth seems to have been driven substantially by yield growth, particularly in wheat and rice. This is associated with growing levels of use of all inputs, especially fertilizers. Fertilizer use showed significant acceleration along with the increase in the growth rate of foodgrain production in several regions in the second half of the green-revolution period.

# 4

# INPUT USE AND PRODUCTION BEHAVIOR

Growth of foodgrain production in India has been accompanied by substantial increases in the use levels of modern inputs, especially fertilizers, HYVs, and irrigation (Table 9 and Figure 6). Fertilizer use on foodgrains has grown dramatically from an average of 18,000 tons in 1949/50-1951/52 to an average of almost 5.0 million tons in 1981/82-1983/84. (The sources and methods for arriving at input data are given in Appendix 4.) The increase in fertilizer use has been even more dramatic since the green revolution (post-1967/68). Between 1967/68-1969/70 and 1981/82-1983/84 the estimated quantities of fertilizers applied to foodgrains increased by more than five times. Including the quantities applied to other crops, the total use of fertilizers reached 7.7 million tons in 1983/84.

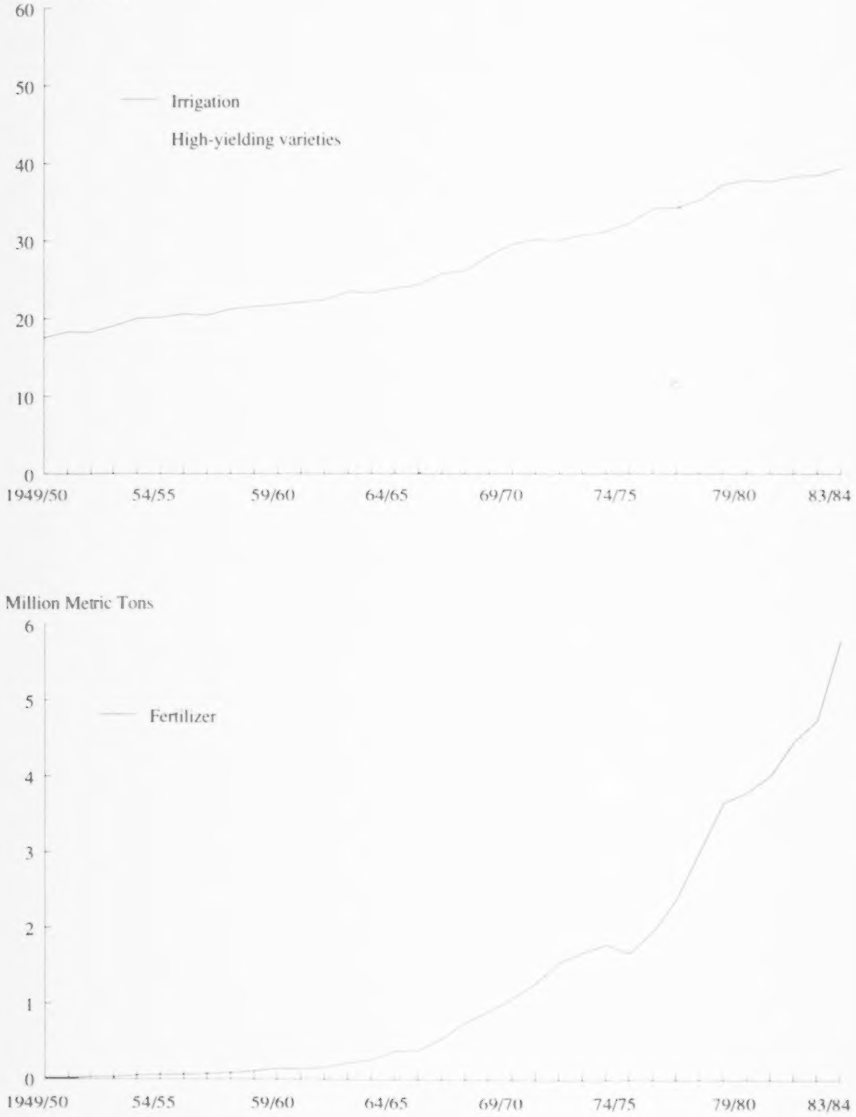
The HYVs that ushered in the green revolution in 1967/68 have also spread rapidly from an average coverage of 8.8 million hectares during 1967/68-1969/70 to 49.2 million hectares during 1981/82-1983/84. The larger part of this growth, nearly 26 million hectares, came between 1967/68-1969/70 and 1975/76-1977/78—an average of 3.2 million hectares a year. Progress was less rapid between 1975/76-1977/78 and 1981/82-1983/84, when less than 14.5 million hectares were added—an average of 2.4 million hectares a year—possibly in part because of the relatively slow growth of irrigated area. The area under HYVs increased rapidly until 1975/76-1977/78, when it became about equal to the irrigated area under foodgrains. Subsequently, the HYV area has expanded slowly, but it has surpassed the irrigated area—showing that HYVs have spread to unirrigated areas. The irrigated area under foodgrains grew very gradually from an average of 18.0 million hectares in 1949/50-1951/52 to 27.9 million hectares in 1967/68-1969/70 and to 38.7 million hectares in 1981/82-1983/84.

**Table 9—Average input use levels in foodgrain production, all India, 1949/50-1983/84**

| | Three-Year Averages | | |
|---|---|---|---|
| Period | Fertilizer | Irrigation | High-Yielding Varieties |
| | (1,000 metric tons) | (million hectares) | |
| 1949/50-1951/52 | 18.07 | 18.00 | 0.00 |
| 1962/63-1964/65 | 281.48 | 23.53 | 0.00 |
| 1967/68-1969/70 | 907.42 | 27.87 | 8.82 |
| 1975/76-1977/78 | 2,458.40 | 34.50 | 34.79 |
| 1981/82-1983/84 | 4,996.41 | 38.69 | 49.24 |

Sources: The basic source is Fertilizer Association of India, *Fertilizer Statistics,* various issues (New Delhi: FAI, various years); for other sources and methods see "Input Data" in Appendix 4.

**Figure 6—Inputs in foodgrain production, 1949/50-1983/84**



Sources: The basic source is Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years); for other sources and methods see "Input Data" in Appendix 4.

Between 1975/76-1977/78 and 1981/82-1983/84, fertilizer use grew by 103 percent, whereas HYV area grew by 42 percent and irrigated area by only 12 percent (Table 9). Thus production growth and acceleration in the second part of the green-revolution period may be related largely to rapid increase in fertilizer use. Growth in yields of wheat and rice after the mid-1970s may also have been due to improvements in the range of available HYVs to suit different environments, strengthening of the extension system, and expansion of input supply systems, which facilitated the expansion of input use. Input response will be examined later.

The increase in input use levels for fertilizers and HYVs has not been gradual but has come in spurts and plateaus (Figure 6). Fertilizer increase showed some leveling off around 1965/66, which was the severe drought period, again around 1972/73-1973/74, about the time when the first oil shock resulted in the doubling of fertilizer prices, and yet again around 1979/80, which was a drought year as well as the time of the second oil shock. Growth in the area under HYVs showed a plateau around 1970/71 and again around 1977/78-1978/79. For both fertilizers and HYVs, the early 1980s saw a growth spurt, which is reflected in a spurt in foodgrain output. Irrigation showed a relatively slow and gradual growth throughout the 35-year period from 1949/50 to 1983/84.

## Analysis with Response Coefficients

Since inputs and output have been increasing together, with spurts and plateaus, it is not obvious how input productivities have been changing over time. In order to do a preliminary examination of this issue, an aggregate response analysis was done using prior values of average response coefficients (input-output ratios). The response coefficients were obtained from Sarma and Roy (1979) (see "Basis of Response Coefficients" in Appendix 4). The values are area, 0.45 tons per hectare; irrigation, 0.50 tons per hectare; shift to wheat/rice, 0.33 tons per hectare; and fertilizers, 10 tons per ton of nutrient (NPK). It is assumed in the above coefficients that the fertilizer coefficient includes the effect of HYVs. The analysis was done across three selected time points, and three-year average input and output levels were used to reduce the effect of weather-related fluctuations. Table 10 presents the results of the analysis. For 1969-72 the difference between the output predicted on the basis of input levels and response coefficients and the actual output is only of the order of 2 million tons, or about 2 percent, indicating that the response coefficients are broadly valid and hold in this period. However, for 1981-84 the actual output falls short of the expected output by almost 10 million tons.

This large divergence between the expected and the actual output seems to indicate a decline in one or more of the aggregate input response coefficients. In simulating to find which input coefficient may be mainly in question, it is found that changing the coefficients of area, irrigation, or shift to wheat/rice cannot help resolve the large difference between expected and actual output. This brings the focus to the fertilizer response coefficient. The analysis shown in Table 10 indicates that if the fertilizer response coefficient is reduced from 10 to 7, the difference between expected and actual output is reduced to about 1 million tons. On this basis, the analysis suggests a likely reduction in the aggregate fertilizer response coefficient from the previously assumed level of 10 to the new likely level of about 7.

## Table 10—Expected production-level analysis using response coefficients

| | | Three-Year Averages of Input Use Levels[a] | | | Expected Contribution of the Input to Production | | Three-Year Averages | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Expected Production | | Actual Production, Three-Year Average | | Difference Between Actual and Expected Production | |
| Input | Assumed Response Coefficient | 1959/60-1961/62 | 1969/70-1971/72 | 1981/82-1983/84 | 1969-72 Over 1959-62 | 1981-84 Over 1969-72 | 1969-72 | 1981-84 | 1969-72 | 1981-84 | 1969-72 | 1981-84 |
| | | | | | (million metric tons) | | | | (million metric tons) | | | |
| Area | 0.45 metric tons/hectare | 115.79 | 123.60 | 128.46 | 3.47 | 2.23 | . . . | . . . | . . . | . . . | . . . | . . . |
| Irrigation | 0.50 metric tons/hectare | 22.10 | 29.90 | 38.69 | 3.90 | 4.40 | . . . | . . . | . . . | . . . | . . . | . . . |
| Shift to wheat/rice | 0.33 metric tons/hectare | 47.56 | 55.68 | 63.37 | 2.68 | 2.54 | . . . | . . . | . . . | . . . | . . . | . . . |
| Fertilizer | 10.00 metric tons/ton | 0.15 | 1.29 | 5.00 | 11.47 | 37.04 | . . . | . . . | . . . | . . . | . . . | . . . |
| Total | . . . | . . . | . . . | . . . | 21.52 | 46.21 | 102.13 | 148.34 | 104.36 | 138.40 | + 2.23 | −9.94 |
| Fertilizer, alternative | 7.00 metric tons/ton | . . . | 1.29 | 5.00 | . . . | 25.93 | . . . | . . . | . . . | . . . | . . . | . . . |
| Total | . . . | . . . | . . . | . . . | . . . | 35.09 | 102.13 | 137.22 | 104.36 | 138.40 | . . . | + 1.18 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); Fertilizer Association of India, *Fertilizer Statistics,* various issues (New Delhi: FAI, various years); and "Basis of Response Coefficients" in Appendix 4.

[a] Area, irrigation, and shift to wheat/rice are in million hectares; fertilizer is in million metric tons.

Since a substantial amount of the increase in fertilizer use is reported to have taken place through increasing concentration of its use in a small number of districts in the country (see Desai 1986, Bhalla and Tyagi 1989, and Fertilizer Association of India 1987/88), this decline in the response seems likely as diminishing marginal returns become more important in weight and strength. As fertilizers are expected to play a crucial role in achieving future growth in production, this decline in productivity is of serious policy concern. It appears that whereas concentration of use would tend to make the diminishing marginal product more important in determining the aggregate response coefficient, diffusion would tend to make the average product, which could be higher, more important. Thus policies for diffusing fertilizer use to areas where its average response is high may be important in raising aggregate fertilizer productivity. The effectiveness of these policies may be aided by an in-depth study of the response function environment across regions. Further, given that much of the fertilizer use is only in the form of nitrogen, the deficiency of other nutrients may be getting critical and contributing to reducing fertilizer productivity, especially in high-use areas. Poor application of organic manures may also be contributing to the decline in the productivity of fertilizers. However, it is observed that during the study period, despite the decline in productivity even without any favorable changes in the price environment, fertilizer use continued to grow rapidly, implying that it was still privately profitable. But the issue of declining productivity remains of considerable national as well as private concern for future growth in foodgrain production.

The above analysis is not able to show precisely when and how this decline in productivity came about. To explore the issue further, the expected output was calculated for each year using the annual input data series and the basic response coefficients given above (10 for fertilizer). The expected output thus calculated was plotted with the actual output and this is shown in Figure 7.[9] The plot shows that actual output fluctuated around expected output from year to year (mainly due to weather fluctuations), but until 1977/78 it stayed around the expected output. However, after 1977/78, actual output fell below the expected and stayed below, even in good crop years. This shows that the fall in input productivities is likely to have been relatively recent and appears to have occurred gradually after 1977/78. A plot of expected output using a response coefficient of 7 for fertilizer has also been made for the post-1977/78 period (Figure 7) and appears to be closer to actual output in this period. This is again indicative of the likely decline in fertilizer response from 10 to 7, but shows that the major fall may have come mainly after 1977/78.

## Rainfall Index

The time-series analysis of relationships between inputs and outputs for Indian agriculture requires consideration of the effect of rainfall. This is because rainfall can have an important effect on agricultural production in India and because rainfall varies considerably from year to year across agroclimatic regions. Even by 1980/81, less than

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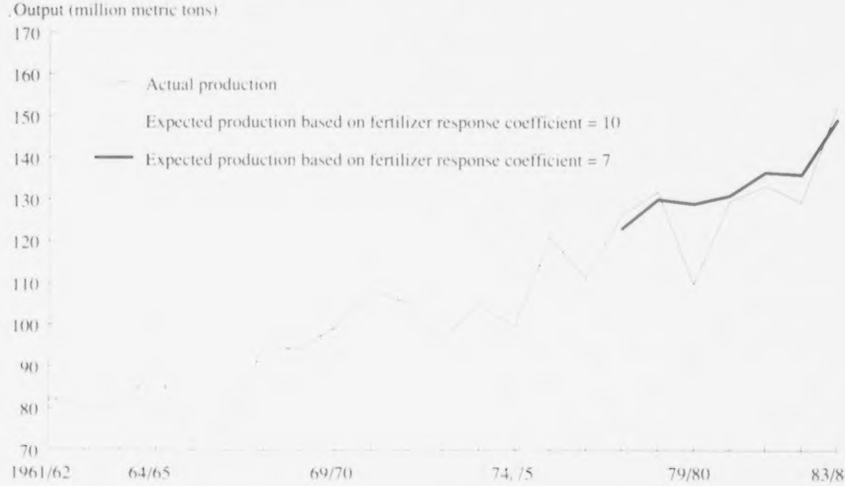
[9] Estimating annual utilization of fertilizers using linear rates of increase and relating the production potential created to fluctuating production is open to objection. It can at best give an approximate relationship, and caution is required in reaching conclusions from these data.

Figure 7—Fertilizer input response in foodgrain production, 1961/62-1983/84



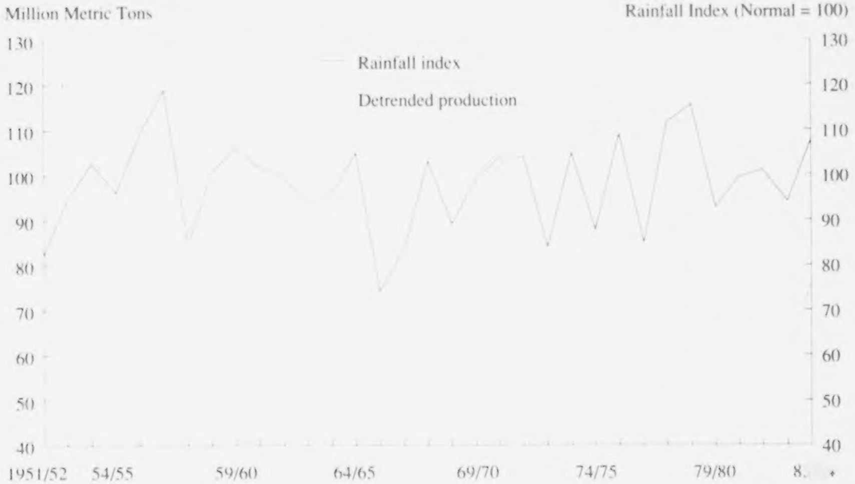
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years); and "Basis of Response Coefficients" in Appendix 4.

30 percent of the cropped area was irrigated, and therefore dependence on rainfall continues to be great.

Though rainfall data are collected throughout the country on a daily basis, until recently very little systematic use has been made of them in crop production studies. One effort to use rainfall data for cereal production analysis in India was that of Cummings and Ray (1969). They used data on rainfall received in different seasons of each year (southwest monsoon, postmonsoon, winter, and premonsoon) in 31 separate rainfall divisions of the country to construct an all-India rainfall index using an elaborate weighting scheme based on cropping pattern and estimates of area and production in different divisions and states. This original index from Cummings and Ray, for which the complete methodology is known, is available from 1951/52 to 1968/69 and has been extended to 1977/78 by Sanderson and Roy (1979) following (as stated by them) the same methodology. In the present study an attempt has been made to develop an improved and updated weighting scheme in constructing a rainfall index for foodgrains. However, due to limitations in the availability of data, the improved indices could be computed only for the period 1973/74-1983/84 (see "Calculation of the Rainfall Index" in Appendix 4). For the earlier period, the Cummings and Ray/Sanderson and Roy indices are used. The overlapping period 1973/74-1977/78 showed that the two indices were highly correlated and close, and therefore there should be little difficulty in merging them.

Figure 8, which gives a plot of the rainfall index along with detrended actual foodgrain production, shows that the index has a close relationship with the actual

## Figure 8—Rainfall index and detrended foodgrain production, 1951/52-1983/84



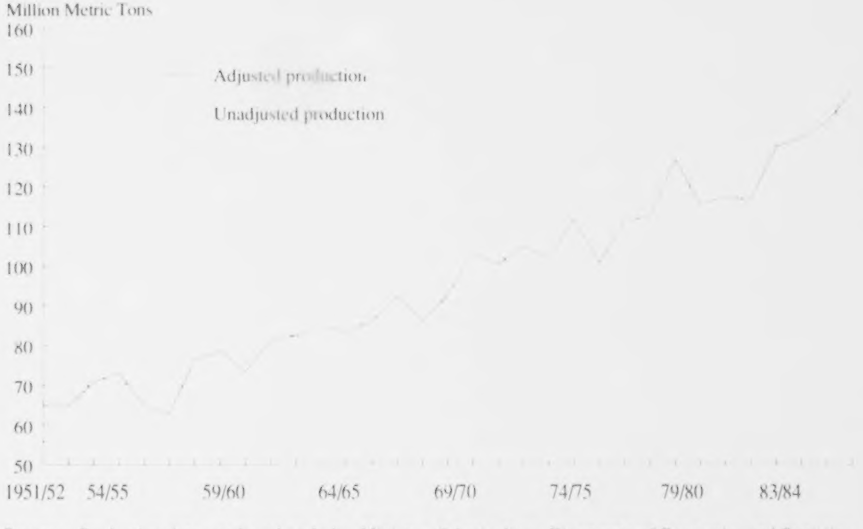
Sources: Production data are based on India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendixes 2 and 4 for other sources and details.

foodgrain production. The tracking of fluctuations in production is somewhat better through the period 1973/74-1983/84 with the improved index calculated in this study. Prior to 1973/74 movement in the rainfall index does not agree with movement in production in 7 of the 22 years, but there is no disagreement in the movement after 1973/74.

An effort has also been made to simulate a time series on weather-adjusted foodgrain production. A Cobb-Douglas production function is estimated using the actual foodgrain production and the estimated rainfall index. This is then used to simulate the foodgrain production at rainfall index = 100 (normal rainfall). The resultant weather-adjusted production series and the actual foodgrain production are plotted in Figure 9. This indicates, for example, the great impact of bad weather on lowering foodgrain production in 1965/66 and 1966/67, and that of good weather on raising foodgrain production in 1977/78 and 1978/79. The plot also shows that the 1983/84 rise in foodgrain production goes beyond weather-related fluctuations.

Table 11 presents a comparison between some important parameters estimated on the basis of weather-adjusted production versus those estimated from unadjusted production. The long-term growth rate in production is about the same for both series, as should be expected. However, there are some differences between the two among the subperiods. In particular, the increase in growth rate between the first and second halves of the green-revolution period not only persists in the weather-adjusted series but is greater. This confirms, beyond the effects of weather, that there was an acceleration in foodgrain production in the second half of the green-revolution period. The unadjusted production series shows a doubling of the coefficient of variation between

## Figure 9—Weather-adjusted foodgrain production, 1951/52-1983/84



Sources: Production data are based on India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendixes 2 and 4 for other sources and details.

the pre-green-revolution and the green-revolution period when calculated after detrending, thus indicating a sharp rise in variability. However, the weather-adjusted series shows an increase of only 34 percent in the coefficient of variation, indicating a lesser rise in variability once weather effects are removed in both periods.

## Table 11—Weather-adjusted and unadjusted foodgrain production: growth rates and coefficients of variation

| Period | Actual Unadjusted Production | Weather-Adjusted Production |
|---|---|---|
| | Growth Rate (percent/year) | |
| 1952/53-1983/84 | 2.47 | 2.46 |
| 1952/53-1964/65 | 2.33 | 2.42 |
| 1967/68-1975/76 | 1.91 | 1.79 |
| 1975/76-1983/84 | 2.48 | 2.61 |
| | Coefficient of Variation (detrended production) | |
| 1952/53-1964/65 | 6.17 | 5.85 |
| 1967/68-1983/84 | 12.07 | 7.82 |

## Factor Analysis

Foodgrain production is affected by a multitude of variables. It is useful from the standpoint of analysis to sort these variables into groups, characterize the groups, and broadly assess their relative importance. One systematic method of achieving this is factor analysis.[10] Factor analysis was, therefore, carried out on several explanatory variables of foodgrain production, namely, area under foodgrains, area under rice and wheat, fertilizers, area under HYVs, irrigated area, and rainfall. The analysis may be useful in identifying important independent factors and also in showing those variables that are not independent in the data and therefore fall in the same factor. The summary results of factor analysis are shown in Table 12 (the complete results are given in Appendix 5). The eigenvalues show that among the six explanatory variables included, only three major factors can be identified. The first factor accounts for 78 percent of the variation (this is total variation and not variability around trend). The correlations with the explanatory variables in the rotated factor matrix show that because of its close relation to fertilizers, HYVs, and irrigation, this factor can be characterized as the technology/inputs factor. Since all three of these variables—fertilizers, HYVs, and irrigation—load on to the same factor, they seem to be moving closely together and may be highly correlated. This indicates that in production function analysis their

**Table 12—Summary of factor analysis results for foodgrain production**

| Principal components on six variables | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Cumulative percentage of eigenvalues | 0.78397<br>78 percent | 0.94596<br>16 percent | 0.99250<br>5 percent | 0.99753<br>. . . | 0.99899<br>. . . | 1.0000<br>. . . |
| Rotated factor matrix—(three factors) | | | | | | |
| Factors | 1 | 2 | 3 | | | |
| Factor idenfitication | Technology/ Inputs | Rainfall | Area | | | |
| | | (correlations) | | | | |
| Variables | | | | | | |
| afg (area) | 0.50537 | 0.19469 | *0.83767* | | | |
| arw (rice/wheat) | 0.72269 | 0.10649 | 0.67787 | | | |
| frfg (fertilizer) | *0.93102* | 0.08348 | 0.33185 | | | |
| hvfg (high-yielding varieties) | *0.91506* | 0.08495 | 0.38171 | | | |
| irfg (irrigation) | *0.81075* | 0.01938 | 0.57895 | | | |
| rain (rainfall) | 0.06285 | *0.99221* | 0.10688 | | | |

Note: Detailed results are given in Appendix 5.

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[10] In order to further understand the relationship between inputs and outputs, factor analysis and production function analysis are done. The former works only with explanatory variables or the inputs in this case. This analysis takes the entire variation in the block of explanatory variables and divides it into orthogonal components or factors that are "parallel" or similar within themselves but "perpendicular" or independent from one another. Two characteristics of these factors are then reported. One is their eigenvalues, which in percentage terms show how much of the total variation is explained by each factor. The second is their correlation with each of the explanatory variables, which shows the explanatory variables the factor is closely related to. The second helps to identify the factors that may be behind the explanatory variables when groups of them are closely related (Green 1978).

individual effects on output may become difficult to separate because of the problem of multicollinearity.

The second factor, which carries 16 percent of the variation, is very closely related to rainfall and may be called the rainfall factor. Its share of the variation is substantially lower than that of the technology/inputs factor. The third factor is most closely related to area and carries 5 percent of the total variation. The factor analysis also shows that area and technology inputs have a moderate and positive correlation, but area and rainfall have only a small positive correlation, and inputs and rainfall have almost no correlation. This is indicative of a relatively weak empirical relationship between rainfall and area, and between rainfall and inputs.

## Production Function Analysis

Production function analysis was carried out using time-series data in an attempt to directly assess the relationship between inputs and output. This was done on an input-output basis without bringing in prices; price response was expected to be reflected through changes in input use. Further, area was eliminated from the relationship by taking yield per hectare as the dependent variable.[11] Area under rice/wheat was also dropped, since it accentuated multicollinearity, and because it was not found very useful, especially when fertilizers, HYVs, and irrigation were all included.

The functional forms tried (presented for a two-input case) are $y_t$ = yield, $x_{it}$ = inputs, $e_t$, $u_t$, and $v_t$ are error terms, and the rest are parameters; t is the time subscript.

Linear:

$$y_t = a_0 + a_1 x_{1t} + a_{2t} x_{2t} + e_t. \tag{1}$$

Cobb-Douglas:

$$y_t = b_0 x_{1t}^{b_1} x_{2t}^{b_2} u_t. \tag{2}$$

This is linearized for estimation by taking the logarithm of both sides:

$$\log y_t = \log b_0 + b_1 \log x_{1t} + b_2 \log x_{2t} + \log u_t. \tag{3}$$

Transcendental:

$$y_t = c_0 x_{1t}^{c_1} e^{d_1 x_{1t}} x_{2t}^{c_2} e^{d_2 x_{2t}} v_t. \tag{4}$$

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[11] Most researchers have found that the input-output relationships are estimated better with yield per hectare as the dependent variable rather than production.

For estimation of parameters, this is linearized by taking the logarithm:

$$\log y_t = \log c_0 + c_1 \log x_{1t} + d_1 x_{1t} + c_2 \log x_{2t} + d_2 x_{2t} + \log v_t. \tag{5}$$

One criterion for selecting these functional forms is parsimony of parameters, that is, fewer parameters to be estimated, and this becomes important given the high multicollinearity and the limited degrees of freedom (see Fuss, McFadden, and Mundlak 1978). The linear form is the simplest but has the most restrictive production behavior assumptions, such as constant marginal productivities. With the same number of parameters, the Cobb-Douglas form has more acceptable assumptions but assumes constant elasticities and allows little flexibility to the shape of the production frontier. The transcendental form doubles the number of parameters to be estimated but is theoretically attractive, since it allows considerable flexibility in the shape of the input-output response frontier (see Halter, Carter, and Hocking 1957). It can accommodate increasing, decreasing, and classical production functional forms.

All of the above functional forms assume separability between inputs, which is a limitation. However, relaxing this assumption requires moving into other forms such as translog and quadratic (full), but these forms greatly add to the parameter load, and given the problem of multicollinearity and limited degrees of freedom, experimentation showed that their empirical results were poor, unstable, and unrealistic. A principal-components approach, as suggested by Mundlak (1981), was also attempted to get over the problem of multicollinearity. This, however, brought little improvement in the results with the given data. The reasons for such an outcome seem evident from the results of the factor analysis, which showed that fertilizer, HYVs, and irrigation all load very strongly on to one and the same factor, and only rainfall could be separated as a distinct factor. Thus the principal-components approach could not effectively overcome the problem of multicollinearity between fertilizer, HYVs, and irrigation. However, results of regressions between principal components and yield indicated that the component that represented fertilizers, HYVs, and irrigation explained 85 percent of the variation in the yield (total variation), whereas the component that represented rainfall explained about 5 percent.

This study does not address technical change as evaluated in general aggregate economic analyses, but only as reflected in the growth in use of modern inputs of irrigation, fertilizers, and HYVs. Irrigation is often considered a lead variable in technical change, but examination of past changes in India indicates that development of irrigation by itself might not have brought about growth in the other two inputs and therefore the rapid growth in yield. Each input, it appears, has required its own investment and efforts and has made its own contribution. Therefore, it would be incorrect to relate all technical change to irrigation. The framework leaves out some inputs such as labor, power, and machinery. One important reason for this omission is that it is extremely difficult to get accurate information on the actual use levels of these inputs. Besides, some of them, such as labor, may not be strongly constraining and may be surplus, so their quantities may not be instrumental in determining production changes. To the extent that this is not true, it may cause an excluded variable upward bias of the coefficients, some of which is frequently unavoidable. Further, this analysis does not use cross-state data. A cross-state production function analysis, though interesting, might not be accurate because of large differences in soils, agroclimatic conditions, cropping patterns (as indicated in Chapter 3), and more, most of which would be difficult to fully incorporate through measurable variables and available data. Incomplete incorporation could cause unknown biases, leading to difficulty in making inferences. Therefore, aggregate analysis was preferred here.

Apart from checking theoretical consistency, a major cross-check of the empirical results was done by computing input-output coefficients at the mean from the estimated production function parameters, and these were compared with estimates of response coefficients accepted in the research literature and used in Indian planning and projection work, as discussed above in connection with Sarma and Roy (1979). The empirical results are presented in Tables 13 and 14 (variable definitions are in Appendix 6). In terms of $R^2$ and F statistics, all the functional forms show good fits. In the linear case, all the parameters have the right signs, but the t-statistic significance of each coefficient—except that for rainfall—is weak, showing that partial response frontier fits of this functional form are not strong. There is substantial improvement of the significance in the Cobb-Douglas functional form, indicating the greater efficacy of this form. However, the HYV coefficient has an incorrect sign. The function also seems to exaggerate the input-output coefficient of irrigation and underestimate the coefficients of fertilizers and HYVs. The transcendental functional form, on the other hand, exaggerates the effect of fertilizers and HYVs but makes the input-output coefficient of irrigation negative. This "sharing of the cake" problem manifested in the instability of coefficients appears to be an outcome of the high multicollinearity between fertilizers, HYVs, and irrigation brought out in the factor analysis. These results also show how unreliable it could be to test only one functional form, especially without comparing it with prior values for coefficients.

One alternative under this multicollinearity problem was to force a prior value on the irrigation coefficient. Thus the transcendental function was reestimated, with the irrigation input-output coefficient being fixed at 0.5, a value frequently accepted for India (see Sarma and Roy 1979). This last restricted transcendental function gives the following input-output coefficients for each of the inputs: 5.50 for fertilizers (note that the HYV effect is segregated), 0.50 for HYVs, 0.50 (by restriction) for irrigation, and 0.34 for rainfall. The good tracking of actual yields by this function is shown in Figure 10.

The input-output coefficient of HYVs shows that for every million hectares of increase in the coverage of HYVs, there is a 0.5 million-ton increase in production of foodgrains. Further, an examination of the magnitude and significance of coefficients in different functional forms indicates that HYVs show a positive semilogarithmic nature of response. This indicates that the spread of HYVs may hold considerable potential for increasing foodgrain production.

Rainfall appears to be showing close to a classical production function response. The standard deviation of the rainfall index is about 10 points and gives a coefficient of variation of 10 percent, which is not as high as may have been expected. It probably shows that there is substantial regional compensation between good and bad rainfall areas in most years. Only in a rare year is the rainfall adverse for the country as a whole, and the statistical variability of the all-India foodgrain rainfall index does not appear very high when studied over the past 33 years. Further, the rainfall input-output coefficient is estimated to be 0.34, which implies that, on an average, a one-standard-deviation (10 points) drop in the rainfall index (one standard deviation covers 65 percent of a normal distribution) reduces foodgrain production, through yield change, by 3.4 million tons. This may not be considered large in percentage terms relative to the 1981/82-1983/84 average production level of about 140 million tons. Rainfall would also influence production through changes in the area. Preliminary analysis on this shows that detrended area is also highly correlated with the rainfall index. But the

## Table 13—Production function estimation results, 1951/52-1983/84

| Functional Form | Estimation (N = 33) |
|---|---|
| Linear | $\text{YIELD} = \underset{(0.19)}{40.60} + \underset{(1.48)}{3.50}\cdot\text{FERT} + \underset{(0.73)}{2.37}\cdot\text{HYV} + \underset{(1.77)}{15.02}\cdot\text{IRRG} + \underset{(4.30)}{3.39}\cdot\text{RAIN}$<br>Adjusted $R^2 = 0.94$ F statistic = 118.4 Durbin-Watson = 1.38 |
| Cobb-Doublas | $\text{LOG(YIELD)} = \underset{(2.51)}{1.89} + \underset{(2.06)}{0.039}\cdot\text{LOG(FERT)} - \underset{(-0.92)}{0.0090}\cdot\text{LOG(HYV)}$<br>$+ \underset{(3.73)}{0.74}\cdot\text{LOG(IRRG)} + \underset{(6.77)}{0.53}\cdot\text{LOG(RAIN)}$<br>Adjusted $R^2 = 0.94$ F statistic = 127.5 Durbin-Watson = 1.61 |
| Transcendental | $\text{LOG(YIELD)} = \underset{(-0.90)}{-5.65} + \underset{(1.05)}{0.0032}\cdot\text{FERT} + \underset{(2.67)}{0.072}\cdot\text{LOG (FERT)}$<br>$+ \underset{(3.40)}{0.012}\cdot\text{HYV} - \underset{(-0.75)}{0.0088}\cdot\text{LOG(HYV)} - \underset{(-1.30)}{0.095}\cdot\text{IRRG}$<br>$+ \underset{(0.85)}{1.60}\cdot\text{LOG(IRRG)} - \underset{(-2.45)}{0.023}\cdot\text{RAIN} + \underset{(2.73)}{2.50}\cdot\text{LOG(RAIN)}$<br>Adjusted $R^2 = 0.97$ F statistic = 123.1 Durbin-Watson = 2.19 |
| Transcendental (forcing irrigation I-O coefficient to 0.50) | $\text{LOG(YIELD)} = \underset{(-2.28)}{-12.21} + \underset{(1.24)}{0.0040}\cdot\text{FERT} + \underset{(1.90)}{0.034}\cdot\text{LOG(FERT)}$<br>$+ \underset{(2.74)}{0.0081}\cdot\text{HYV} - \underset{(-2.17)}{0.022}\cdot\text{LOG(HYV)} - \underset{(-2.07)}{0.15}\cdot\text{IRRG}$<br>$+ \underset{(2.16)}{3.54}\cdot\text{LOG(IRRG)} - \underset{(-2.78)}{0.026}\cdot\text{RAIN} + \underset{(3.23)}{2.97}\cdot\text{LOG(RAIN)}$<br>Adjusted $R^2 = 0.97$ Durbin-Watson = 2.35 |

Notes: The numbers in parentheses below parameter estimates are t-statistics. Results are strongly affected by multicollinearity between irrigation, fertilizers, and high-yielding varieties. The implied input-output (I-O) coefficients from these regression estimates are given in Table 14. The transcendental production function gives the greatest flexibility to the shape of the production frontier vis-à-vis each input. Other functional forms such as translog and quadratic were also tried. These forms introduce interaction terms that greatly increase the variable load, and this coupled with the already great multicollinearity problem leads to poor and unstable results.

Definitions of variables:

YIELD = yield of foodgrains in kilograms per hectare,
FERT = fertilizer use in kilograms per hectare,
HYV = percent coverage of high-yielding varieties in foodgrain area,
IRRG = percent coverage of irrigation in foodgrain area, and
RAIN = all-India foodgrain rainfall index.

estimated impact on production through the area from a one-point change in the rainfall index is only about one-third in magnitude compared with the impact on production through the yield, at the mean.

The above analysis shows that though rainfall is a very important factor in determining India's foodgrain production, with a high statistical significance in all func-

## Table 14—Implied input-output coefficients at mean from production function estimates

| Functional Form | Fertilizer | High-Yielding Varieties | Irrigation | Rainfall |
|---|---|---|---|---|
| | (metric tons/ton) | (metric tons/hectare) | | (million metric tons/ index point) |
| Linear | 3.50 | 0.24 | 1.50 | 0.40 |
| Cobb-Douglas | 2.74 | −0.06 | 2.51 | 0.50 |
| Transcendental | 7.57 | 0.86 | −2.04 | 0.24 |
| Transcendental (forcing irrigation I-O coefficient to 0.5) | 5.49 | 0.50 | 0.50 | 0.34 |
| Additional estimates | | | | |
| Transcendental (forcing irrigation I-O coefficient to 0.4) | 5.58 | 0.52 | 0.40 | 0.34 |
| Transcendental (forcing irrigation I-O coefficient to 0.25) | 5.70 | 0.54 | 0.25 | 0.33 |
| Transcendental (excluding high-yielding varieties) | 9.10 | . . . | 0.33 | 0.36 |
| Transcendental (excluding high-yielding varieties and forcing irrigation I-O to 0.5) | 8.64 | . . . | 0.50 | 0.36 |

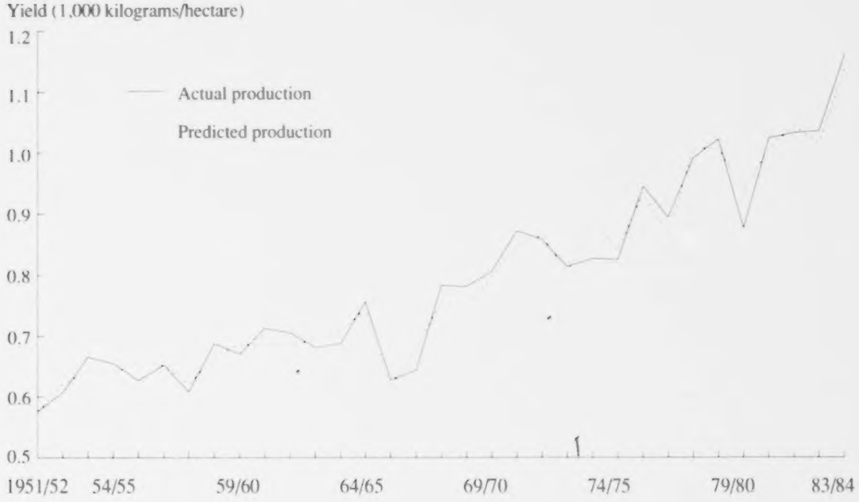
Notes: In the linear case the yield equation regression coefficient directly gives the marginal productivities. In order to obtain the input-output (I-O) coefficients in the units given above, the high-yielding varieties and irrigation coefficients need to be divided by 10, and for rainfall the coefficient needs to be multiplied by (118.71/1000). In the Cobb-Douglas case, the yield equation regression coefficients give the elasticities, which can be converted to derivatives at mean by multiplying with (mean yield/mean input level). These can be converted to input-output coefficients using the same methods as for linear. For the transcendental case, following Halter, Carter, and Hocking (1957), the derivatives at mean can be calculated as follows: $dy/dx = y(a/x + b)$, where $y$ is mean yield, $x$ is mean input level, $a$ is coefficient of log input terms, and [illegible] coefficient of linear input terms. The derivatives can be converted to input-output coefficients using the same methods as for linear.

tional forms, its average variability for the country as a whole is not extremely high when evaluated over the past 33 years. Further, when studied over many years, its effect on total foodgrain production in the country may not be as great as often assumed. An interesting area of further research could be to examine the impact of two or three consecutive bad rainfall years on foodgrain production.

Table 13 also shows several additional estimates obtained through alternative assumptions in the production function analysis. Since a prior value of 0.50 was forced for the irrigation input-output coefficient, it became important to check the sensitivity of the estimates to this assumption. The results show that varying the irrigation input-output coefficient to 0.40 and to 0.25 causes only a small change in the input-output coefficients of fertilizers, HYVs, and rainfall.

In the earlier approach of studying input response, the effect of HYVs was included under the fertilizer response, and no distinction was made between HYVs and fertilizers. To simulate this, the HYV variable was dropped from the equation, and the equation was reestimated. The results show that the fertilizer input-output coefficient under this assumption comes to 9.10 (at the mean), and for irrigation the coefficient comes to 0.33. To provide comparability with the earlier estimate, the irrigation input-output coefficient was forced to 0.50, and the results show that this causes a small reduction in the fertilizer input-output coefficient to 8.64. This result obtained through production function analysis supports those obtained earlier through the analysis using

**Figure 10—Production function: actual and predicted values, 1951/52-1983/84**



Source: Based on results of the second transcendental equation in Table 13.

response coefficients. The response coefficient analysis indicated a decline in the response for fertilizers, from a response of the order of 10 in the 1960s and early 1970s to a response of the order of 7 in more recent years. The production function analysis indicates a comparable response at the mean of 8.6. This supports the hypothesis that there has been a decline in the aggregate fertilizer response. Since fertilizers are expected to play a crucial role in the future growth of foodgrain production, this decline in the response is of major policy concern.

## Yields under High-Yielding Varieties and Irrigation

This section provides some further facts on yields obtainable with HYVs and irrigation, since these could not be fully dealt with within the framework and methods above because of the multicollinearity problem.

In 1983/84 the area under HYVs reached a level of 54 million hectares, of which rice and wheat accounted for about 41 million. A shift to HYVs is expected to increase yields, and the available data on HYV yields in selected states indicates that the differentials between HYVs and local varieties are relatively high but have a wide variation from state to state. The HYV yields for wheat in 1983/84 were about 3.0 tons per hectare in Punjab, 2.7 tons in Gujarat, and 2.5 tons in Haryana, whereas in other states they ranged only from 1.0 to 2.0 tons per hectare. For rice the HYV yields were 3.0 tons per hectare in Punjab and West Bengal, followed by Haryana (2.7 tons) and summer rice in Karnataka (2.5 tons). The yields quoted above are state average HYV yields based on the results of crop-cutting experiments. The wide differences in state HYV yields can be attributed to variations in soil fertility, input use, and adoption of improved agricultural practices, including water management. In Punjab, HYV yields may be relatively high because of 91 percent irrigation of the foodgrain area and a high rate of fertilizer application (143 kilograms per hectare in 1983/84). On the other hand, in the Central region states of Madhya Pradesh and Rajasthan the average yields are low, possibly because of less irrigation and low per hectare use of fertilizers (Table 15). These yields indicate that the HYV yields are higher than average, and the yield differentials across states indicate that there may be scope for further improvement, even in HYV yields.

Irrigated area under foodgrains reached a level of 40 million hectares by 1983/84. Foodgrain yields under irrigation are generally known to be higher than those without irrigation. Aggregated data on average yield per hectare of irrigated and unirrigated foodgrains are not available. However, disaggregate data on irrigated yields in selected states based on crop-cutting experiments indicate that irrigated wheat yield in Punjab was 3.1 tons per hectare in 1983/84. In Gujarat and Haryana the irrigated yield averaged 2.7 and 2.5 tons, respectively, whereas in the remaining states it was about 2 tons per hectare or lower. In rice, again Punjab led with 3.1 tons per hectare, followed by West Bengal with 2.7 tons (winter crop). In West Bengal, however, irrigated summer rice yielded 3.9 tons per hectare. These yields actually represent the combined effects of irrigation, HYVs, chemical fertilizers, and associated improved practices. These yields also show that the yields under irrigation are higher than average, and the yield differentials across states indicate that there could be further scope for increasing irrigated yields.

**Table 15—Irrigation, high-yielding variety, and fertilizer use, and crop yields in selected states, 1983/84**

| Item | Punjab | Madhya Pradesh | Rajasthan |
|---|---|---|---|
| Irrigated area under foodgrains to total cropped area (percent) | 91.0 | 13.2 | 18.9 |
| Yield of irrigated rice (metric tons/hectare) | 3.1 | 1.5 | 1.8 |
| Yield of irrigated wheat (metric tons/hectare) | 3.1 | 1.8 | 1.7 |
| Area under HYVs to total area under foodgrains (percent) | 89.9 | 22.1 | 21.8 |
| Yield of HYV rice (metric tons/hectare) | 3.0 | 1.7 | . . . |
| Yield of HYV wheat (metric tons/hectare) | 3.0 | 1.9 | 1.9 |
| Fertilizer use (kilograms/hectare) | 143.1 | 14.5 | 11.3 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India, 1985-86* (Delhi: Controller of Publications, 1987); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Indian Agriculture in Brief* (Delhi: Controller of Publications, 1986).

Note: HYV = high-yielding variety.

## 5

# TRENDS AND CHANGES IN PER CAPITA CONSUMPTION OF FOODGRAINS

Statistics on per capita consumption of foodgrains in India are available from two separate sources that use entirely different methods. The Ministry of Agriculture annually computes and reports in its *Bulletin on Food Statistics* the per capita availability of foodgrains, using net production, net imports, changes in government stocks, and midyear population. These estimates are essentially based on supply-utilization accounts and use the disappearance concept. The second source is the National Sample Survey Organization (NSSO) of the Department of Statistics, which reports data on per capita consumption of foodgrains in quantity and value terms from household consumer surveys that are currently conducted every five years. The National Sample Survey (NSS) data are, therefore, based on direct estimation of consumption through the interview method. These permit a more disaggregate examination of the consumption levels and patterns. This chapter uses both of the above estimates to examine the trends, levels, and patterns of consumption, in rural and urban areas, by crop and by quartile group.

## Per Capita Availability

The data on net availability of foodgrains do not account for changes in private stocks with trade, farmers, or consumers, as data on these are not readily available. The net production is obtained by subtracting from the gross production an overall predetermined allowance of 12.5 percent for seed, feed, and wastage.[12] Ideally, the seed use estimate should be based on seed rates and areas under different crops, and the rates relative to production would have changed considerably, especially after the introduction of HYVs. The feed use estimate should be based on the feeding ratios and measures of livestock output, and the wastage should be determined separately as a percentage of the foodgrain output. However, in the absence of any representative survey data giving alternative rates and ratios for these, there was no feasible way around these weaknesses in the data. Therefore, these weaknesses having been mentioned, the Ministry's figures on net production and per capita availability are used in the following analysis.

Figure 11 gives a plot of the annual national per capita availability of foodgrains from 1951 to 1984. It shows that availability has fluctuated considerably but without a

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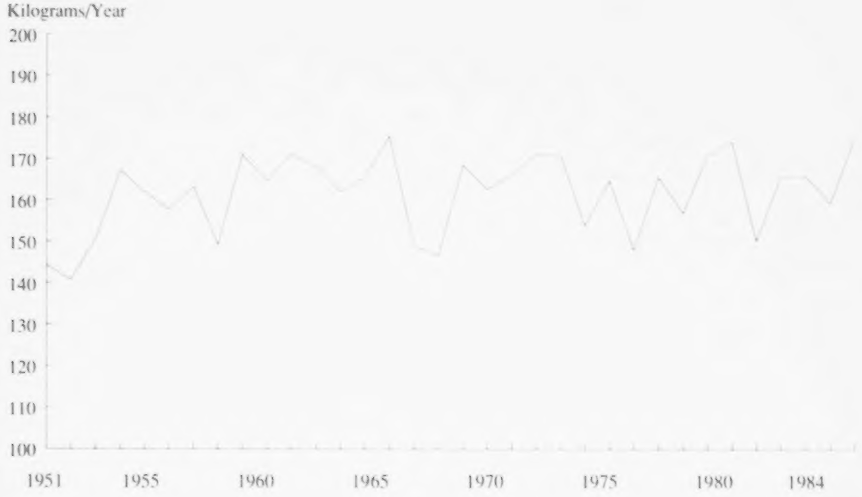
[12] Different percentages are applied to different foodgrains: for rice the allowance is 7.6 percent, for wheat, 12.1 percent, and for the aggregate of cereals and pulses, 12.5 percent.

Figure 11—Per capita availability of foodgrains, 1951-84



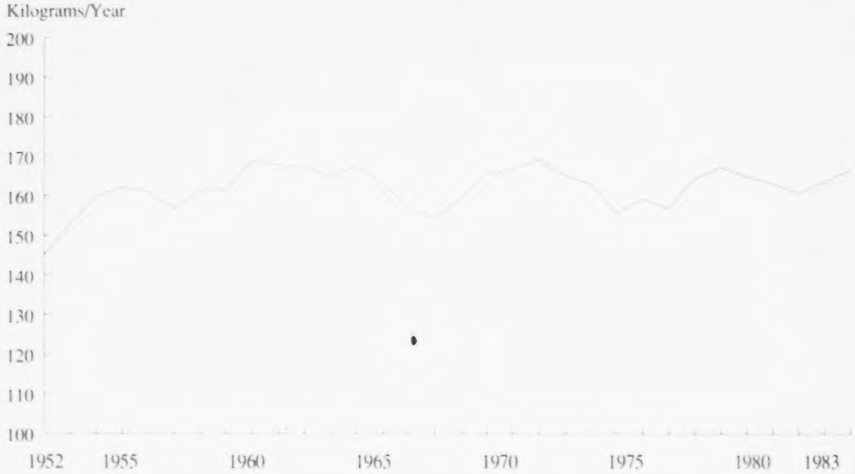
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

major trend. The following table gives estimated compound growth rates of per capita availability and their t-statistics for different periods.

| Time Period | Growth Rate (percent/year) | t-Statistic |
|---|---|---|
| 1951-84 | 0.19 | 1.85 |
| 1951-65 | 1.10 | 3.94 |
| 1968-84 | negligible | 0.03 |
| 1968-76 | −0.79 | −1.32 |
| 1976-84 | 0.27 | 0.39 |

The results show that the trend growth rate for the period 1951-84 as a whole is only 0.2 percent a year and is statistically insignificant. The first subperiod (1951-65), which is the pre-green-revolution part, shows an increase in per capita consumption of 1.1 percent a year. However, the green-revolution period (1968-84) shows no trend in either the first (1968-76) or second (1976-84) part. Thus, except in the pre-green-revolution period, the per capita availability figures show very little overall improvement or deterioration. Figure 12 gives a plot of a centered three-year moving average of per capita availability. This shows that the per capita average availability fluctuates in a band approximately between 150 kilograms and 170 kilograms a year for the period from 1952 to 1983.

Figure 12—Per capita availability of foodgrains: three-year moving average, 1952-83



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Sarma and Roy (1979) reported a 6.2 percent decline in per capita availability of foodgrains in 1975-77 compared with the level in 1970-72.[13] Table 16 shows that the average per capita availability declined from 169.3 kilograms a year in 1970-72 to 156.7 kilograms a year in 1975-77. Subsequently, the per capita availability rose again to 166.6 kilograms a year in 1982-84. However, it remains to be seen why per capita availability fell substantially in 1975-77 compared with 1970-72. Related data in Table 16 show that there were increases in the net production of cereals, net imports, and per capita income, along with a decrease in the real price of foodgrains, and yet there was a decline in per capita availability. An increase in government stocks more or less absorbed the increase in cereal imports. To further analyze this implicit change in consumption behavior during 1970-84, the annual net production of foodgrains per capita and the real prices of foodgrains were calculated on a time-series basis, and these were plotted along with per capita availability (Figure 13). The following observations can be made from this analysis.

1. The per capita availability and the per capita net production series move closely together (the difference between the two can be accounted for by per capita imports and changes in stocks).

2. Especially in 1975 and to some extent in 1977, the per capita net production was much lower than in the early 1970s, and, coupled with the higher (total) net production

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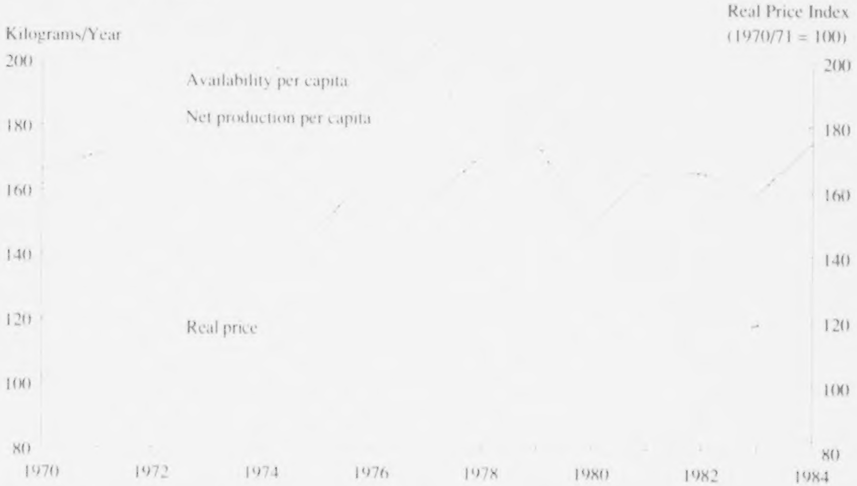
[13] The decline in availability in the mid-1970s was also a global phenomenon for developing countries; grain production declined in both developed and developing countries, causing a drawdown in stocks and reduction in grain trade.

## Table 16—Changes in net availability of foodgrains across selected years, 1970-84

| Item | 1970-72 Average | 1975-77 Average | 1982-84 Average |
|---|---|---|---|
| Per capita availability of foodgrains (kilograms/year) | 169.3 | 156.7 | 166.6 |
| Net production of cereals (million metric tons) | 81.2 | 86.8 | 110.5 |
| Net import of cereals (million metric tons) | 1.8 | 4.8 | 2.7 |
| Net production of pulses (million metric tons) | 10.1 | 10.0 | 10.6 |
| Real price index of foodgrains (wholesale) (1970/71 = 100) | 100.3 | 94.6 | 84.8 |
| Per capita income (constant rupees/year) | 624.0 | 644.0 | 734.0 |
| Population (millions) | 551.4 | 617.3 | 720.4 |
| Change in government stocks of cereals (million metric tons) | −0.3 | + 4.9 | + 3.7 |
| Net availability of foodgrains (million metric tons) | 93.4 | 96.8 | 120.1 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

## Figure 13—Per capita availability, net production, and real prices of foodgrains, 1970-84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

of foodgrains in this period, this implies that though production increased, it could not keep pace with the increase in population. The 1.9 percent annual rate of growth in foodgrain production during 1967-76 was lower than the population growth rate of 2.3 percent.

3. In 1976, there was a sharp decline in the real prices of foodgrains. At least partly due to this decline, there was a large apparent transfer of foodgrain stock holdings from the unrecorded/unaccounted private sector to the recorded/accounted government sector. This was estimated by Sarma and Roy (1979) to be of the order of 2 million tons on an average during 1975-77. Such a shift in stocks would have an effect of relative underestimation of per capita human consumption since per capita availability does not take into account changes in private stocks. This would account for a difference of about 3.2 kilograms per capita. Thus the decline in per capita availability between 1970-72 and 1975-77 can be explained mainly in terms of production growth not keeping pace with population growth, and to some extent in terms of a relative underestimation of per capita availability in 1975-77 due to a shift of stocks from private to government hands.

Figure 13 also shows that the real prices of foodgrains fell significantly in the second half of the 1970s compared with their high levels in the first half, and these depressed real prices continued into the 1980s. Another observation is that government operations through stocks and imports appear to have been helpful in supplementing domestic procurement and in meeting requirements under the public distribution system. However, given that one of the objectives of the operation was stabilization of consumption, Figure 13 indicates that the government operations were unable to substantially dampen the instability in per capita availability arising from fluctuations in production. This, however, does not take into account the effects of private stocks. The above observations seem to indicate the indispensability of sustained growth in production for raising and stabilizing foodgrain consumption.

## National Sample Survey Consumption Estimates

As mentioned earlier, the NSSO conducts all-India sample surveys that examine the levels and patterns of consumption of foodgrains and other items of consumption for both rural and urban consumers across income (total consumer expenditure) groups. Until 1973/74 the consumption surveys were conducted annually, but since then they have been conducted approximately every five years.[14] These surveys cover random samples of up to 150,000 households from all over the country and report consumption by major item, usually in per capita expenditures and quantities, but often and for many items, only in expenditure terms. For the 1977/78 and 1983 surveys, quantitative data on consumption of pulses are not available. The methodology followed for deriving quantity data from the expenditure data on pulses is described in Appendix 7.

Table 17 presents the average per capita consumption of cereals, pulses, and foodgrains at the rural, urban, and national levels from 1961/62 to 1983 based on NSS data. The figures show that about 94 percent of the foodgrains consumed are cereals and only 6 percent are pulses. The NSS data show a decline in the per capita consumption of foodgrains from the 1960s to the 1970s. For instance, between 1961/62 and

[14] Most of the NSSO's consumption surveys use the split-year basis of July to June. One exception was 1983, which was based on the calendar year.

## Table 17—Per capita consumption of foodgrains, 1961/62-1983

| | | Monthly Consumption[a] | | | Annual Consumption | |
|---|---|---|---|---|---|---|
| Year | Grain | Rural | Urban | National | National[a] | Average per Capita Availability[b,c] |
| | | | | (kilograms) | | |
| 1961/62 | Cereals | 17.55 | 12.49 | 16.63 | ... | ... |
| | Pulses | 1.50 | 1.53 | 1.51 | ... | ... |
| | Total | 19.05 | 14.02 | 18.14 | 220.7 | 167.1 |
| 1964/65 | Cereals | 16.19 | 11.65 | 15.32 | ... | ... |
| | Pulses | 1.66 | 1.18 | 1.56 | ... | ... |
| | Total | 17.85 | 12.83 | 16.88 | 205.4 | 163.2 |
| 1970/71 | Cereals | 15.35 | 11.36 | 14.56 | ... | ... |
| | Pulses | 0.96 | 1.01 | 0.97 | ... | ... |
| | Total | 16.31 | 12.37 | 15.53 | 188.9 | 169.3 |
| 1972/73 | Cereals | 15.29 | 11.27 | 14.45 | ... | ... |
| | Pulses | 0.85 | 0.93 | 0.87 | ... | ... |
| | Total | 16.14 | 12.20 | 15.32 | 186.4 | 165.2 |
| 1973/74 | Cereals | 15.09 | 11.32 | 14.30 | ... | ... |
| | Pulses | 0.88 | 0.82 | 0.87 | ... | ... |
| | Total | 15.97 | 12.14 | 15.17 | 184.6 | 155.5 |
| 1977/78 | Cereals | 15.25 | 11.62 | 14.44 | ... | ... |
| | Pulses[d] | 1.01 | 1.07 | 1.02 | ... | ... |
| | Total | 16.26 | 12.69 | 15.46 | 188.1 | 167.2 |
| 1983 | Cereals | 14.80 | 11.30 | 13.96 | ... | ... |
| | Pulses[d] | 1.02 | 1.13 | 1.04 | ... | ... |
| | Total | 15.82 | 12.43 | 15.00 | 182.5 | 166.6 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics,* various issues (Delhi: Controller of Publications, various years).

Notes: The estimates of per capita availability derived from the Ministry of Agriculture's figures and those of per capita consumption obtained from the National Sample Survey are not strictly comparable for a number of reasons (see Appendix 7 for details). Parts may not add to totals because of rounding.

[a] Based on National Sample Survey consumption figures, which are on a July-June survey-year basis except for 1983, which is on a calendar-year basis.

[b] Based on Ministry of Agriculture per capita availability figures, which are provided on a calendar-year basis.

[c] The per capita availability shown against year 1961/62 (July-June) is the three-year average for calendar years 1961 to 1963, and so on for all years except 1983, when all figures are directly on a calendar-year basis.

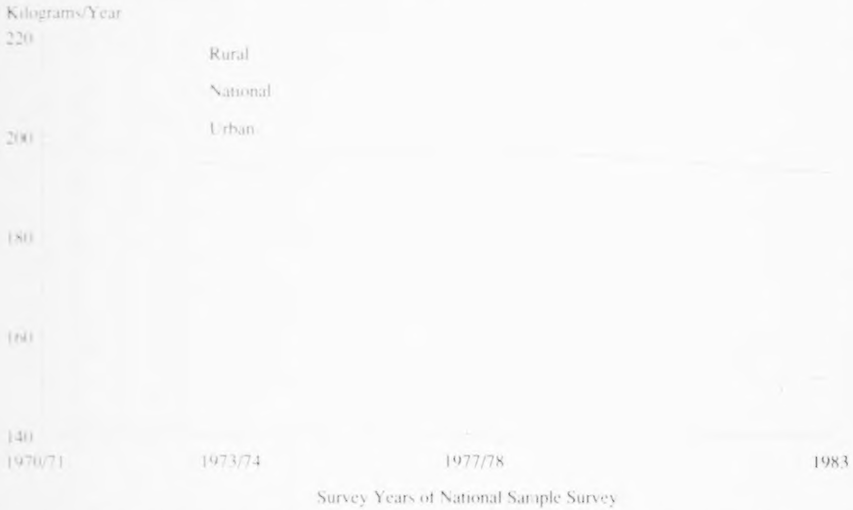
[d] Estimated.

1970/71 consumption declined from 220.7 kilograms a year to 188.9 kilograms, a reduction of 14.4 percent. In 1973/74 it declined further to 184.6 kilograms a year. It rose again to 188.1 kilograms in 1977/78, though in 1983 per capita consumption declined to 182.5 kilograms. Relative to the difference between the 1960s and 1970s, the changes in per capita consumption since 1970/71 have been small and have been in both directions, and since the per capita consumption is captured for only one year out of several years, they may reflect year-to-year fluctuations. Underlying price changes may also hold some explanation, and these will be discussed later.

In order to examine further the difference in the per capita consumption between the 1960s and 1970s, average per capita availability figures were calculated from the Ministry of Agriculture's data for comparison for the years corresponding to NSS surveys. Strictly speaking, the estimates of per capita availability, which are based on the disappearance concept, cannot be directly compared with the NSS estimates of consumption, which are obtained by the interview method, in part because the availability figures do not reflect changes in private stocks. The NSS data relate to household consumption only and do not include nonhousehold consumption such as that of hotels. However, broad comparisons are possible, and for this purpose, three-year-average per capita availabilities with the designated year as the midyear have been computed and are presented in Table 17. The availability figures indicate a much smaller change from the early 1960s to the early 1970s and show a 1.3 percent increase between 1961/62 and 1970/71 (compared with a 14.4 percent decrease shown by the NSS data). Several studies, including Vaidyanathan 1986, Suryanarayana and Iyengar 1986, Mukherjee 1986, and Minhas 1988, also indicate that the NSS estimates of per capita consumption in the early 1960s may be relative overestimates. Thus it seems that the NSS data may exaggerate the decline in consumption from the 1960s to the 1970s. There is a difference in magnitudes between the NSS consumption figures and the per capita availability figures, and this continues into the 1970s and 1980s to as much as 12-15 percent, but the gap is relatively stable in these years.

Figure 14 shows a large difference between the rural and urban consumption levels of foodgrains, based on the NSS data. This is of the order of 50 kilograms a year and could be a result of own-foodgrain production and consumption in the rural areas, rural-urban price difference due to market margins, different preferences due to higher incomes in the urban areas, and variety of foods available in the urban markets. Figure 14 also shows small changes in national per capita foodgrain consumption between 1970/71 and 1983. Consumption shows a small decline from 1970/71 to 1973/74, an increase from 1973/74 to 1977/78, and a decrease from 1977/78 to 1983. Given that NSS estimates consumption in only one year of several years, this may tend to reflect

**Figure 14—Per capita consumption of foodgrains, 1970/71-1983**



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

the year-to-year fluctuations rather than trends. Rural and urban per capita consumptions show similar patterns over time. The difference between 1970/71 and 1983 may be partly due to changes in relative prices, which will be discussed later.

The overall consumption of pulses declined from 1.56 kilograms a month in 1964/65 to 0.87 kilograms by 1972/73 but subsequently increased to about 1.02 kilograms per capita by 1977/78 and remained more or less at that level in 1983. The difference between the rural and urban per capita consumption of pulses was very marginal in most years.

Figure 15 shows the 1977/78 per capita consumption of cereals, pulses, and foodgrains across income (total expenditure) groups in the rural areas in 1977/78. In the following discussion, income refers to its proxy: total expenditure in constant 1970/71 prices.[15] The consumption of foodgrains initially rises steeply with the rise in incomes but gradually levels off. The near-saturation level for the rural areas is about 27 kilograms a month, or 329 kilograms a year. Pulse consumption, which is nearly zero at the bottom income levels, rises to about 2.5 kilograms a month, or 30.0 kilograms a year, at the high income levels. In the urban areas, foodgrain consumption reaches near saturation at around 15.0 kilograms a month, or 183.0 kilograms a year, and pulse consumption reaches a level of about 2.0 kilograms a month, or 24.0 kilograms a year, at the highest income levels. These figures show the large difference between the levels of rural and urban direct consumption of foodgrains per capita. Given these food consumption patterns, it appears that income growth in rural areas can have a potentially greater total impact on direct foodgrain demand than similar changes in urban areas.

Table 18 shows the per capita monthly consumption of rice, wheat, and coarse grains in rural and urban areas, based on the NSS results. The data show declining consumption of coarse cereals in both rural and urban areas. The consumption of wheat in rural areas increased relatively faster than in urban areas. Consequently, the rural-urban disparity in wheat consumption narrowed considerably — perhaps partly because of the rapid expansion of fair-price shops distributing cheaper wheat in rural areas, particularly in the deficit states. Rapid expansion of area and production of wheat and its introduction into new areas also contributed to increased wheat consumption. Consumption of rice in rural areas grew steadily though slowly between 1970/71 and 1977/78. The per capita consumption of rice in urban areas in 1973/74 and 1977/78 was lower than in 1970/71.

In order to bring about comparability for the study of consumption levels across income groups at different time points, several adjustments were made in the data. The rural and urban income group means were deflated to 1970/71 prices by the agricultural-labor consumer price index and the working-class consumer price index, respectively. Nonavailable quantity data posed special problems in the case of pulses in 1977/78 and 1983 because past data showed that prices varied significantly across income groups — possibly because of differences in the composition and quality of foodgrains consumed. As a solution, the mean prices of pulses were moved forward using wholesale price indices for pulses, and the price distribution across income groups, estimated from 1970/71, was used to generate the prices at each income group level on the basis of its real relative value. (Details of this procedure are given in

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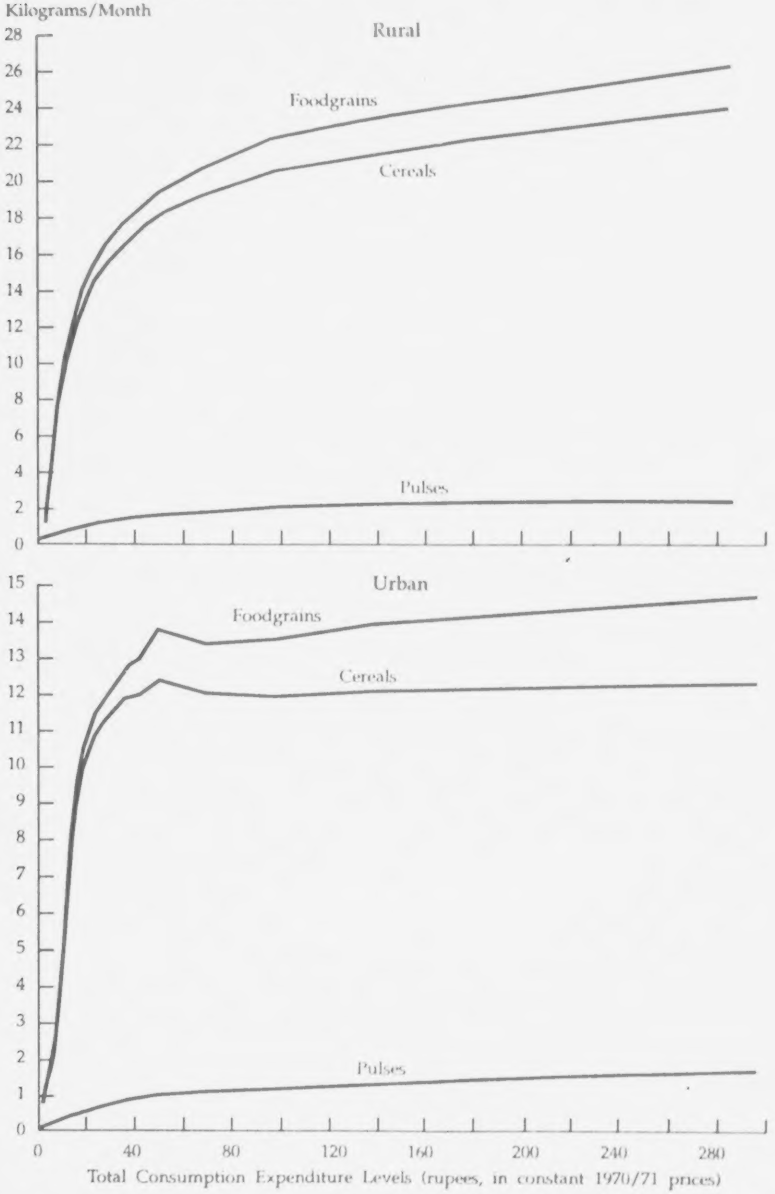
[15] The use of total expenditure as a proxy for income has some limitations in the sense that it understates the income in the top quartile, which has a higher propensity to save, and may overstate the income in the bottom quartile, which may have a tendency to dissave.

Figure 16—Per capita consumption of foodgrains, rural and urban, 1977/78



Source: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, Round 32 (1977/78) (New Delhi: NSSO, 1984).

## Table 18—Per capita monthly consumption of cereals, 1970/71-1983

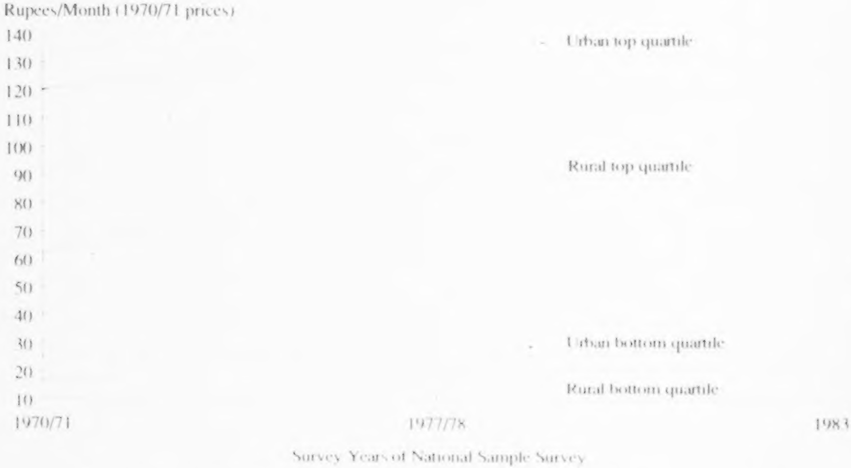
| | Rural | | | | Urban | | | |
|---|---|---|---|---|---|---|---|---|
| **Cereal** | **1970/71** | **1973/74** | **1977/78** | **1983** | **1970/71** | **1973/74** | **1977/78** | **1983** |
| | (kilograms) | | | | | | | |
| Rice | 6.85 | 6.90 | 7.12 | 6.63 | 5.53 | 5.38 | 5.48 | 5.32 |
| Wheat | 2.78 | 3.52 | 4.05 | 4.46 | 4.12 | 4.32 | 4.87 | 4.82 |
| Coarse grains | 5.72 | 4.67 | 4.08 | 3.71 | 1.71 | 1.62 | 1.27 | 1.16 |
| Total cereals | 15.35 | 15.09 | 15.25 | 14.80 | 11.36 | 11.32 | 11.62 | 11.30 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years); see Appendix 7 for details.

Appendix 7.) The computed comparable data were then used in a quartile analysis of consumption.

Figure 16 and Table 19 show total expenditure (total consumer expenditure) levels of the top and bottom, urban and rural, quartiles in constant 1970/71 prices. Considering total expenditure as a proxy for income, this figure shows that the income of the urban top quartile is substantially higher than that of the rural top quartile and that both the top quartiles are four to five times higher than the bottom quartiles. The total expenditure disparities in the urban as well as the rural areas appear to have increased

## Figure 16—Total per capita consumer expenditure levels, by quartile, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

## Table 19—Per capita foodgrain consumption and total consumer expenditures, rural and urban, top and bottom quartiles, 1970/71-1983

| | Foodgrain Consumption | | | | Total Expenditure[a] | | | |
|---|---|---|---|---|---|---|---|---|
| | Rural Quartiles | | Urban Quartiles | | Rural Quartiles | | Urban Quartiles | |
| Year | Top | Bottom | Top | Bottom | Top | Bottom | Top | Bottom |
| | (kilograms/month) | | | | (rupees/month) | | | |
| 1970/71 | 20.56 | 11.90 | 12.83 | 11.02 | 61.95 | 16.77 | 120.39 | 25.20 |
| 1977/78 | 21.11 | 12.32 | 13.92 | 10.96 | 91.23 | 19.37 | 134.54 | 25.21 |
| 1983 | 20.29 | 12.67 | 13.90 | 11.00 | 86.19 | 22.12 | 130.03 | 27.90 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years); see Appendix 7 for details.

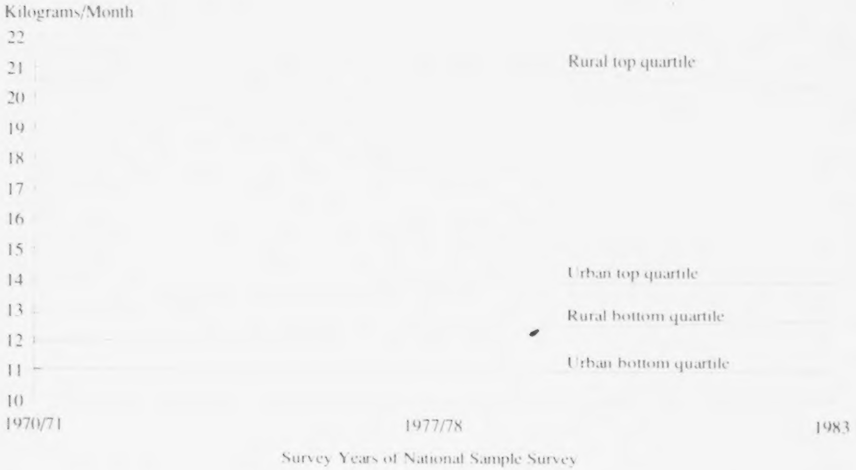
[a] At 1970/71 prices.

from 1970/71 to 1977/78 but decreased from 1977/78 to 1983. The rural-urban total expenditure disparities lessened over this entire period. The compound annual growth rates of total expenditure (income) of the different quartiles between 1970/71 and 1983 are rural top, 2.6 percent; rural bottom, 2.2 percent; urban top, 0.6 percent; and urban bottom, 0.7 percent. From this it appears that the rural total expenditures, though lower, may be improving faster at both the upper and lower income levels. Rural bottom quartile incomes show continuing growth from 1970/71 to 1983, which is encouraging, but the 2.2 percent rate of growth appears too small to raise this group rapidly from their low income levels. On the other hand, the income level of the urban bottom quartile shows an even smaller improvement, growing at a rate of only 0.7 percent.

Figure 17 and Table 19 give the per capita foodgrain consumption of different quartiles, showing the substantially higher level of foodgrain consumption of the rural top quartile. There was a small decline in this consumption level between 1970/71 and 1983, from 20.56 kilograms a month to 20.29 kilograms. However, foodgrain consumption of the urban top quartile increased from 12.83 kilograms a month in 1970/71 to 13.90 kilograms in 1983, and that of the rural bottom quartile also improved from 11.90 kilograms a month in 1970/71 to 12.67 kilograms in 1983. But the consumption of the urban bottom quartile was stagnant at about 11.00 kilograms a month. Thus, whereas the disparities in foodgrain consumption between income levels are decreasing in the rural areas, they are increasing in the urban areas. This is confirmed by the following compound growth rates of foodgrain consumption between 1970/71 and 1983: rural top, –0.10 percent; rural bottom, 0.50 percent; urban top, 0.60 percent; and urban bottom, –0.01 percent. The 0.50 percent growth rate of the rural bottom quartile, though positive, is itself not very encouraging, and the stagnation in consumption of the urban bottom quartile at the already low level is of great concern.

The growth in foodgrain consumption of the urban top quartile was about 8.3 percent, which is related to a growth of 8.0 percent in its total expenditure in the same period, but this 8.0 percent probably understates the growth in income of the top quartile, which generally has a high marginal propensity to save. This increase in consumption may also be partly because of the generally improved availability of foodgrains in the free market since the early 1970s and particularly after 1978. The decline in real prices of foodgrains may also have been sharper for urban areas than the average. This is supported by George (1979), who reported that the increase in nominal

**Figure 17—Per capita foodgrain consumption levels, by quartile, 1970/71-1983**



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

prices of foodgrains has been less sharp in urban than in rural areas. This issue requires further investigation, since it has an important bearing on demand.

Mellor (1978) has shown that even though the poor have a smaller absolute expenditure on food, the impact of a food price increase falls most heavily on them because food has a large budget share in their total expenditure. Ezekiel (1990) has shown that because the poor tend to have relatively higher income and price elasticities of demand for food, in the event of a shortage and price increase the bulk of adjustment in demand takes place through a reduction in consumption of the poor. Given these observations, and given relatively slow growth in foodgrain consumption despite some rise in incomes, the underlying changes in the relative prices of foodgrains for different consumer groups merited further analysis. These changes were examined through the calculation of implicit prices paid by consumers in each quartile, in both urban and rural areas, on the basis of the NSS consumer expenditure and quantity data. The results, presented in the form of indices in Table 20, demonstrate that even though wholesale prices show a sizable decline in the real prices of cereals, consumer prices do not show as much decline in real terms. Whereas the real cereal wholesale price index declined from 100 to 85 between 1970/71 and 1983, the real urban consumer price index for cereals declined only from 100 to 93. The rural consumer cereal price index in fact increased from 100 to 103, and for the rural bottom quartile this index increased from 100 to 106.

The changes in these indices might be considered relatively small, but the differences between some of them seem to be rather large. They indicate divergences from the broad picture indicated by wholesale prices. The increase in the rural real consumer

## Table 20—Implicit nominal and real price indices, by consumer group, 1970/71-1983

| | Nominal Price | | | Real Price | | |
|---|---|---|---|---|---|---|
| Group | 1970/71 | 1977/78 | 1983 | 1970/71 | 1977/78 | 1983 |
| Rural | | | | | | |
| Consumer cereal prices, overall | 100 | 163.4 | 270.5 | 100.0 | 97.1 | 103.4 |
| Quartile 1 (bottom) | 100 | 171.3 | 276.8 | 100.0 | 101.8 | 105.9 |
| Quartile 2 | 100 | 166.4 | 277.2 | 100.0 | 98.9 | 106.0 |
| Quartile 3 | 100 | 163.8 | 273.8 | 100.0 | 97.4 | 104.7 |
| Quartile 4 (top) | 100 | 160.6 | 269.9 | 100.0 | 95.5 | 103.2 |
| Consumer price index, overall | 100 | 168.2 | 261.5 | ... | ... | ... |
| Urban | | | | | | |
| Consumer cereal prices, overall | 100 | 158.6 | 265.1 | 100.0 | 91.3 | 93.2 |
| Quartile 1 (bottom) | 100 | 159.8 | 262.1 | 100.0 | 91.9 | 92.1 |
| Quartile 2 | 100 | 158.4 | 266.0 | 100.0 | 91.1 | 93.5 |
| Quartile 3 | 100 | 154.7 | 260.5 | 100.0 | 89.0 | 91.6 |
| Quartile 4 (top) | 100 | 155.1 | 264.3 | 100.0 | 89.2 | 92.9 |
| Consumer price index, overall | 100 | 173.8 | 284.5 | ... | ... | ... |
| Cereal prices | | | | | | |
| National wholesale | 100 | 157.9 | 256.4 | 100.0 | 86.9 | 85.1 |
| All commodities | | | | | | |
| National wholesale | 100 | 181.6 | 301.4 | ... | ... | ... |

Sources: Rural and urban overall consumer cereal prices are based on data from India, Department of Statistics, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: National Sample Survey Organization, various years); rural and urban overall consumer price indices and national wholesale cereal and commodity prices are based on indices from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Note: The base year for all price indices in this table is 1970/71.

prices for cereals may be due to increasing market coverage and integration, which brings more grains on the market and brings rural prices closer to urban prices. The relatively faster increase in prices for the rural bottom quartile may be due to the increased dependence of these consumers on the market. These changes may also be associated with a shift in the composition of cereal consumption from coarse grains to fine grains, particularly to rice, the price of which has risen somewhat faster than that of other grains. The calculations indicate that despite production breakthroughs the real prices of cereals for rural consumers, particularly those in the bottom quartile, have not declined and in fact seem to show an increase. This could have contributed to a slower growth in the food consumption of the poor and the overall demand, and also indicates that part of the benefits of development to the rural bottom quartile may have been nullified by increases in real food prices.

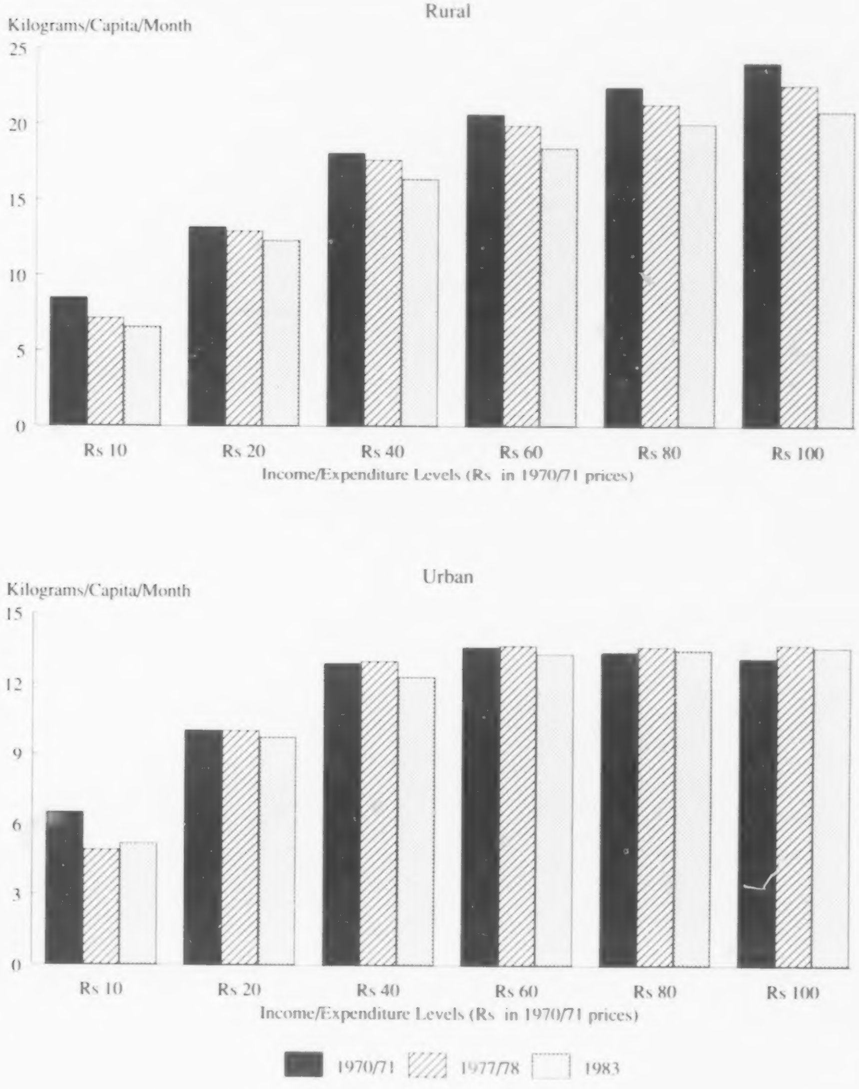
The quartile analysis aggregates foodgrain consumption over the income range of the quartile, which itself may change, and therefore does not give an idea of what the consumption of foodgrains is at specific levels of income, how much this consumption changes from level to level, and how people at specific income levels have moved over time between levels. As mentioned earlier, a common axis of income for comparing the different surveys (at different points in time) has been derived by deflating to the 1970/71 prices with the aid of the relevant consumer price indices. Using linear interpolation with the consumption functions of the type plotted in Figure 15, the levels of foodgrain consumption are calculated at the following interior levels of income (total expenditure) per month: Rs 10, 20, 40, 60, 80, and 100. This calculation is done for each of the surveys, that is, for 1970/71, 1977/78, and 1983.

The results for rural and urban areas are shown in Figure 18. These charts show, surprisingly, that in the rural areas there was a reduction in per capita consumption of foodgrains from 1970/71 to 1983 at each income level. This may be, particularly for upper income levels, partly because of the phenomenon of urbanization of rural consumption patterns, which is caused mainly by improvement in rural infrastructure. The reduction is least at the income level of Rs 20 a month and largest at the high income level of Rs 100 a month. The data show that among the people at the lower income levels (Rs 10-20 a month), foodgrain consumption deteriorated for those who stayed at the same income level. This, coupled with the earlier analysis, shows that the increased foodgrain consumption of the bottom quartile came about primarily because of an increase in incomes in this quartile. It can be seen that an increase in a poor rural individual's income from Rs 10 to Rs 20 raises that person's foodgrain consumption from 6.6 kilograms a month to 12.3 kilograms, or by 5.7 kilograms a month (87 percent). However, an increase in an upper or middle class individual's income from Rs 80 to Rs 100 raises foodgrain consumption by only 0.8 kilograms a month (about 4 percent). This underscores the tremendous impact that poverty alleviation can have on foodgrain demand. It also indicates that skewed or unequal growth can result in slow growth of foodgrain demand. The decline in the rural consumption of foodgrains at the upper income levels between 1970/71 and 1983 adds to the direct demand problem and can probably be explained by substitution, away from an already very high level of foodgrain consumption to other foods and other consumption.

The urban areas show a more skewed pattern than the rural areas. The consumption of the lowest urban income level shows a decline from 6.51 kilograms a month in 1970/71 to 5.20 kilograms in 1983, whereas consumption at the upper income levels of Rs 80 and Rs 100 a month shows a marginal increase between 1970/71 and 1983. Unlike those in the rural areas, the low-income groups in the urban areas show very little growth in income levels to counterbalance this decline in consumption at the low income levels, and therefore foodgrain consumption for the urban bottom quartile shows little change. This decrease at given low real income levels may also be a manifestation of the greater and greater pressure on urban resources and rising living costs due to continuing rural-urban migration. The data show that an increase in a poor urban individual's income from Rs 10 to Rs 20 raises that person's consumption of foodgrains from 5.20 kilograms a month to 9.75 kilograms, that is, by 4.55 kilograms or 88 percent. However, an increase in an upper or middle class individual's income from Rs 80 to Rs 100 raises foodgrain consumption by only 0.10 kilogram or 0.7 percent. This indicates the great impact that poverty alleviation (for instance, through an employment strategy of growth) can have on raising foodgrain demand rapidly. It also shows that growth that is unequal or biased toward upper-income groups can result in slow growth in foodgrain demand.

It can be inferred from the above analysis that a major reason why direct foodgrain demand (or consumption) is not accelerating as fast as might be expected is slow progress in raising the incomes of the poor section of the population, that is, in alleviating poverty, especially in the urban areas. Some (but small) positive progress is seen in this direction in the rural areas, where incomes and foodgrain consumption in the bottom rural quartile are increasing. The results indicate that programs to help development that can generate more employment and incomes for the poor are of great importance and could significantly raise foodgrain demand.

Figure 18—Per capita rural and urban foodgrain consumption at different income levels, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey. Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

# 6

# SCENARIOS FOR THE YEAR 2000

The previous chapters have examined the dynamics and behavior of some major components and elements in the past growth of foodgrain production and consumption in India. Given the results of this analysis, the present chapter examines possible future scenarios in the evolution of the foodgrain situation in India to the year 2000. On the production side, provided that there is continued strong government emphasis on raising food production and its efficiency, it is anticipated that the past performance in raising overall foodgrain production could continue into the future. In seeking to estimate the broad outcome of this growth by 2000, the past regional area and yield growth rates by crop are used under some limiting assumptions. The response coefficients from the previous production analysis are then used to calculate the physical requirements of this growth in terms of the needs for the different major inputs. These requirements help to present for policy purposes the overall magnitude and various dimensions of the task of raising foodgrain production to the estimated levels.

The processes on the demand and consumption sides of foodgrains are somewhat different, particularly because they depend on the nature and pace of economic growth and the changing patterns of foodgrain demand. In this context, the Indian national plans have set for the future the twin objectives of acceleration of economic growth and elimination of poverty by 2000. What the implications of the achievement of these objectives would be for foodgrain demand has never been carefully analyzed. Considering the obvious importance of such an analysis, this study has examined and estimated the demand for foodgrains under several scenarios, including the continuation of past per capita income growth rates and several alternative scenarios of accelerated growth. Some of these also simulate a small change in income distribution and indicate the implications for foodgrain demand of further progress toward poverty alleviation. Implications of increases in income can also occur in terms of an acceleration in the demand for feedgrain through increased consumption of livestock products. Feedgrain demand is found to be a relatively dynamic component of the total foodgrain demand in a large number of Asian developing countries, especially when income growth rates accelerate. The effect of this is also estimated here and is built into the total demand estimates.

## Production

Most production projections for foodgrains in India are done on an aggregate all-India basis, and implicit in such projections is uniform application of average all-India growth parameters. Given the wide diversity in agroclimatic conditions, cropping patterns, and technological change in India, this may not be an appropriate assumption. This study attempts to work on a regional basis. Earlier in the study the country was subdivided into six regions—Northern, Uttar Pradesh, Central, Western, Eastern, and Southern—on the basis of geographical location and agroclimatic and cropping pattern characteristics. This division is applied here to obtain regional projections for production, thereby developing national projections that better reflect India's diverse agriculture.

Production projections are made separately within each region for rice, wheat, coarse cereals, and pulses. Area and yield are also projected separately for each region (more details are provided in Appendix 8). Given the important differences between the pre-green-revolution period (1949/50-1964/65) and the green-revolution period (1967/68-1983/84), particularly in the acceleration of yield and deceleration of area growth differing from crop to crop, it was decided to base the projections on the growth rates over the 16 years of the green-revolution period. Though foodgrain production growth accelerated in the later part of this period, the entire period was used as the base, since the second half of the period was considered too short a time to base long-term projections on, given the possible instability of short-period growth rates, particularly at the disaggregated levels of regions and crops.

With regard to area, the trend projections to the year 2000, when done on the basis of area under individual foodgrain crops in each region, were, when aggregated, found to differ from the trend projected for the total foodgrain area in the region. As the latter trend was believed to better reflect the overall land constraint, a normalization procedure was used in which the individual projected crop areas were proportionally adjusted to conform to the projected total foodgrain area in the region. Apart from this, the Northern region's foodgrain area growth rate was constrained to 0.5 percent (compared with 1.3 percent in the past), in consideration of the limits to further area growth in this region.

Concerning yield projections, analysis of past trends indicated that in some regions the yield growth rates have been very high, particularly for wheat, often exceeding 3 percent a year. Continuation of such growth rates to the year 2000 appears difficult; therefore, a limiting assumption restricting the yield growth rate to less than or equal to 3 percent a year is made. This affects yield growth rates in rice in the Northern region, wheat in the Uttar Pradesh, Central, Western, and Southern regions, and coarse grains in the Western region. However, where yields have declined, the declines are not projected to continue, and this assumption becomes relevant for crops such as pulses in some regions.

It was shown in Chapter 3 that the growth rate of foodgrain production in the Eastern region has been very poor. For rice, the major foodgrain crop of the region, the yield growth rate (Table 6) has been very low (0.28 percent during 1967/68-1983/84) and yield levels are currently lower than those in several other regions. With the expected emphasis on development of this region, it is assumed that the rice yield growth rate will accelerate to 2.50 percent a year. Such an acceleration will require substantial development effort, and in this context the constraints to agricultural growth and development in the Eastern region have been examined by the Reserve Bank of India Committee on Agricultural Productivity in Eastern India (India, Reserve Bank 1984), headed by S. R. Sen.

The committee considered the region to have a high potential but found the development constrained by institutional, technological, and economic factors resulting substantially from deficiencies in infrastructure, administration, and management. To accelerate the spread of new technology the committee recommended a massive effort from the government toward investment in infrastructure and in bringing inputs within easy reach of the cultivators. To raise agricultural growth in the region the committee recommended well-organized and coordinated implementation of plans that would create incentive-oriented conditions for small farmers, raising the physical production potential through better irrigation and drainage; improvement in the delivery systems for inputs, services, and credit; identification and promotion of a few lead technologies for homogeneous groups of farmers through "tapering" subsidies; research, extension, and education systems that recognize diversity and choice; and strengthening of the marketing systems through evenly spread growth centers in the rural areas. Acceleration of agricultural growth in the Eastern region could also make a significant dent in national poverty alleviation, given the relative concentration of poverty there.

The projected yield levels for the year 2000, based on the above assumptions, are presented in Table 21. Projected wheat and rice yields are highest in the Northern region, reaching 4 tons per hectare. Coarse cereals yields are projected to be highest in the Southern and Western regions, whereas pulse yields are expected to be highest in the Uttar Pradesh region. The interregional yield disparities show a slight reduction, but foodgrain yields in the Northern, Uttar Pradesh, and Southern regions continue to be above the national average, whereas in the Central, Western, and Eastern regions the yields remain below the national average.

The projections of production for 2000 (Table 22) indicate that wheat production will rise to 87 million tons, surpassing rice production of 85 million tons. The production levels of coarse cereals and pulses are projected to rise modestly to 35 and 14 million tons, respectively. These projections put the overall production of foodgrains in India at about 219 million tons by 2000. Rapid foodgrain production growth is projected in the Northern, Uttar Pradesh, and Western regions. Considering the growth rates from the second part of the green-revolution period (1975/76-1983/84) discussed earlier, foodgrain production in the Uttar Pradesh and Central regions may be somewhat higher than these projections, whereas that in the Western region may be lower.

A sizable contribution to production growth is expected to come from rice production in the Northern region and wheat production in the Uttar Pradesh region. Of the incremental production of 79.4 million tons, wheat accounts for 52.0 percent, rice for

## Table 21—Projections of foodgrain yields to year 2000

| Region | Rice | Wheat | Coarse Grains | Pulses | Total Foodgrains |
|---|---|---|---|---|---|
| | | | (kilograms/hectare) | | |
| Northern | 4,680<br>(2,916) | 3,961<br>(2,663) | 1,207<br>(1,100) | 540<br>(540) | 3,828<br>(2,163) |
| Uttar Pradesh | 1,690<br>(1,076) | 2,860<br>(1,783) | 907<br>(828) | 781<br>(781) | 2,221<br>(1,290) |
| Central | 703<br>(693) | 1,849<br>(1,152) | 527<br>(477) | 495<br>(445) | 839<br>(628) |
| Western | 2,267<br>(1,605) | 2,325<br>(1,449) | 1,234<br>(769) | 524<br>(411) | 1,300<br>(857) |
| Eastern | 1,516<br>(1,021) | 2,199<br>(1,670) | 946<br>(800) | 499<br>(499) | 1,443<br>(999) |
| Southern | 2,646<br>(1,943) | 1,176<br>(733) | 1,256<br>(832) | 586<br>(373) | 1,831<br>(1,282) |
| All India | 2,023<br>(1,294) | 2,675<br>(1,779) | 978<br>(718) | 532<br>(486) | 1,627<br>(1,059) |

Source: Calculated by the authors; see Appendix 8 for details.
Note: Figures in parentheses are 1983/84 trend values.

## Table 22—Projections of foodgrain production to year 2000

| Region | Rice | Wheat | Coarse Cereals | Pulses | Total Foodgrains |
|---|---|---|---|---|---|
| | | | (million metric tons) | | |
| Northern | | | | | |
| Projection for 2000 | 21.2 | 22.7 | 1.4 | 0.2 | 45.5 |
| 1983/84 trend production | 6.6 | 14.4 | 2.6 | 0.6 | 24.2 |
| Increment in production | 14.6 | 8.3 | −1.2 | −0.4 | 21.3 |
| Contribution to all-India increment (percent) | (18.4) | (10.5) | (−1.5) | (−0.5) | (26.8) |
| Uttar Pradesh | | | | | |
| Projection for 2000 | 8.4 | 33.1 | 1.8 | 1.2 | 44.4 |
| 1983/84 trend production | 5.8 | 16.5 | 3.4 | 2.3 | 28.1 |
| Increment in production | 2.6 | 16.6 | −1.6 | −1.1 | 16.3 |
| Contribution to all-India increment (percent) | (3.3) | (20.9) | (−2.0) | (−1.4) | (20.5) |
| Central | | | | | |
| Projection for 2000 | 4.2 | 14.2 | 5.8 | 5.0 | 29.2 |
| 1983/84 trend production | 3.6 | 6.8 | 5.9 | 3.9 | 20.2 |
| Increment in production | 0.6 | 7.4 | −0.1 | 1.1 | 9.0 |
| Contribution to all-India increment (percent) | (0.8) | (9.3) | (−0.1) | (1.4) | (11.3) |
| Western | | | | | |
| Projection for 2000 | 7.3 | 7.3 | 17.7 | 3.6 | 35.9 |
| 1983/84 trend production | 4.9 | 3.3 | 11.7 | 2.1 | 22.0 |
| Increment in production | 2.4 | 4.0 | 6.0 | 1.5 | 13.9 |
| Contribution to all-India increment (percent) | (3.0) | (5.0) | (7.5) | (1.9) | (17.5) |
| Eastern | | | | | |
| Projection for 2000 | 23.8 | 9.4 | 2.0 | 1.8 | 37.0 |
| 1983/84 trend production | 18.0 | 4.6 | 1.9 | 1.8 | 26.4 |
| Increment in production | 5.8 | 4.8 | 0.1 | 0.0 | 10.6 |
| Contribution to all-India increment (percent) | (7.3) | (6.0) | (0.1) | (0.0) | (13.4) |
| Southern | | | | | |
| Projection for 2000 | 19.9 | 0.0 | 5.7 | 1.7 | 27.2 |
| 1983/84 trend production | 13.6 | 0.0 | 4.6 | 0.9 | 19.1 |
| Increment in production | 6.3 | 0.0 | 1.1 | 0.8 | 8.1 |
| Contribution to all-India increment (percent) | (7.9) | (0.0) | (1.4) | (1.0) | (10.2) |
| All India | | | | | |
| Projection for 2000 | 84.7 | 86.7 | 34.5 | 13.5 | 219.4 |
| 1983/84 trend production | 52.6 | 45.7 | 30.2 | 11.6 | 140.0 |
| Increment in production | 32.1 | 41.0 | 4.3 | 1.9 | 79.4 |
| Contribution to all-India increment (percent) | (40.4) | (51.6) | (5.4) | (2.4) | (100.0) |

Source: Calculated by the authors; see the following note and Appendix 8 for details.

Notes: Projections are based on 1967/68-1983/84 regional area and yield growth rates. Yield growth rates are constrained to be nonnegative and to be not more than 3.0 percent across all crops and regions. Area growth by crop is constrained in each region and adjusted for the region's past growth rate in total foodgrain area. The Northern region's total foodgrain area growth rate is further constrained to 0.5 percent. In expectation of special efforts in the Eastern region, this region's rice yield growth rate is assumed to accelerate to 2.5 percent. Parts may not add to totals because of rounding.

40.0 percent, coarse cereals for 5.0 percent, and pulses for 2.0 percent. However, the projections by commodity need to be viewed with caution. The continuation of past negative area growth rates to 2000 for coarse grains and pulses, and the normalization procedure adopted to adjust individual projected crop areas to be consistent with the projected foodgrain area result in relatively lower output projections for these crops. The overall output projection of 219.4 million tons in 2000 compared with the base level output of 140 million tons in 1983/84 implies an average compound growth rate of 2.8 percent. This represents acceleration over the past 2.6 percent growth rate in all-India foodgrain production.

Of the 79.4-million-ton increment in production, about one-half is expected to come from the Northern and Uttar Pradesh regions, whereas the Eastern and Southern regions will together contribute less than one-fourth. This is despite the fact that under the yield and area growth caps applied, the Northern region's production growth rate is projected to be 4.0 percent compared with 5.1 percent in the past, and the growth rate of Uttar Pradesh would be 3.0 percent compared with 4.8 percent in the past. At the same time, the Eastern region's production growth rate is assumed to accelerate from −0.22 percent to 2.2 percent. For the Southern region the yield growth rate is high, but since the region has a −1.0 percent area growth rate, showing diversion of area to nonfoodgrain crops (as total cropped area is not declining), it does not make a large contribution to production. The interregional differences in production growth have major implications for interregional trade, income growth, and poverty alleviation. Faster growth in the current surplus areas and slower growth in the others implies a considerable increase in dependence on an efficient foodgrain marketing system. Interregional distribution of rural incomes could become more skewed and this might increase labor migration. However, relatively faster growth in the Eastern region might help reduce the substantial poverty in that region.

Instead of projecting, as above, with the area and yield of each crop or crop group by region, if a projection is done on the basis of area and yield of the aggregate of all foodgrains in each region, the resulting all-India production of foodgrains works out to 211 million tons in 2000 (production scenario 2). An additional assumption made in this scenario is that foodgrain yield in the Eastern region will grow at 2.00 percent a year compared with 0.43 percent a year in the past. In production scenario 3 the projection is made on the basis of the area and yield of foodgrains at the all-India level using all-India area and yield growth rates. The total projected output in this scenario comes to 215 million tons. These results are presented in Table 23.

## Table 23—Alternative projections of area, yield, and production of foodgrains for year 2000

| Scenario | Projection | Area | Yield | Production |
|---|---|---|---|---|
| | | (million hectares) | (kilograms/ metric ton) | (million metric tons) |
| 1 | Based on each crop area and yield projected separately in each region (same as in Table 22) | 134.9 | 1,627 | 219.4 |
| 2 | Based on foodgrain area and yield projected separately in each region | 134.9 | 1,563 | 210.7 |
| 3 | Based on total foodgrain area and yield projected at the all-India level | 130.2 | 1,654 | 215.2 |

Source: Calculated by the authors; see the following note and Appendix 8 for details.

Notes: The projections are based on 1967/68-1983/84 area and yield growth rates. Yield growth rates are constrained to be nonnegative and subject to a ceiling limit of 3.0 percent across all crops and regions. Area growth by crop is constrained in each region and adjusted for the region's past growth rate in total foodgrain area. The Northern region's total foodgrain area growth rate is constrained to 0.5 percent. The growth rate of rice yield in the Eastern region is assumed to accelerate to 2.5 percent. The growth rate of foodgrain yield in the Eastern region is assumed to accelerate to 2.0 percent in scenario 2.

*The projected output of 219-220 million tons of foodgrains in 2000 represents a huge increase of about 80 million tons over the base level trend output of about 140 million tons in 1983/84. Achievement of a production increase of this order will require substantial increases in irrigated area, fertilizer use, and use of HYV seeds, possibly with increases in the area under wheat and rice. Even the maintenance of the past trends in productivity growth will call for continued high priority for a first-rate agricultural research system stressing development of new technology, and emphasis on technology transfer through a strong extension system to farmers' fields in both irrigated and rainfed areas.*

To provide a broad assessment of the order of magnitude of the efforts involved, the input requirements for achieving the additional production of 80 million tons have been worked out using estimates of input response from the production analysis in Chapter 4. Table 24 gives the results of the estimation of input requirements. It indicates that a gross irrigated area of 100 million hectares will be required, of which about 60 percent is expected to be under foodgrains. Achieving the 220-million-ton production level will also require a fertilizer consumption level of about 20 million tons of nutrients (NPK) of which 70 percent is expected to be applied to foodgrains. Given that about 80 percent of the increment in production depends on the increase in fertilizer use, it may be stressed that not only is the achievement of 20 million tons of nutrient use important, but maintenance of the fertilizer response coefficient at a level of 7 or above is crucial. Given the decline in the fertilizer response coefficient from 10 to 7, as shown in Chapter 4, it appears that research, extension, and input diffusion efforts to raise this response would be crucial and would give excellent returns.

## Table 24—Estimated input requirements for projected foodgrain production in year 2000

| Input | Assumed Production Response Coefficient[a] | Input Level, 1981/82-1983/84 Average | Projected Input Level, 1999/2000 | Projected Input Increment | Projected Contribution to Production Increment |
|---|---|---|---|---|---|
| | (metric tons of foodgrains/hectare) | (million hectares) | (million hectares) | (million hectares) | (million metric tons of foodgrains) |
| Area | 0.45 | 128.46 | 134.85 | 6.39 | 2.88 |
| Irrigation | 0.50 | 38.69 | 60.00[b] | 21.31 | 10.65 |
| Shift to wheat and rice | 0.33[c] | 63.37 | 74.30 | 10.93 | 3.61 |
| | (metric tons of foodgrains/ton) | (million metric tons) | (million metric tons) | (million metric tons) | |
| Fertilizer | 7.00 | 5.00 | 14.00[d] | 9.00 | 63.00 |
| Total increment | . . . | . . . | . . . | . . . | 80.14 |

[a] The response coefficients are based on Table 10. The derivation of these response coefficients is discussed in Chapter 4.

[b] Projected irrigated area in 1999/2000 is 100 million hectares, of which 60 percent would be under foodgrains.

[c] This response coefficient is based on the difference in yield levels after excluding the effect of irrigation and fertilizer and is likely to be conservative.

[d] Projected fertilizer use in 1999/2000 is 20 million metric tons, of which 70 percent would be applied to foodgrains.

Arrangements will also be needed for production and distribution of an annual supply of about 5.5 million tons of seeds of both HYVs and other improved varieties.[16] Institutional arrangements for the supply of credit and for marketing and storage of both inputs and outputs to support the increased scale of activity will need to be considerably strengthened. These findings indicate that reaching a foodgrain production of 220 million tons by the year 2000 will without doubt be a formidable task.

## Consumption

The estimation of future foodgrain consumption has been done under several alternative assumptions of income growth and income distribution. The estimation works separately with rural and urban consumption and different commodities, namely, rice, wheat, coarse cereals, and pulses, and with different quartiles. As observed earlier, an average annual gap of as much as 25 kilograms per capita exists between the foodgrain consumption estimates of the NSSO and the per capita availability estimates worked out through supply accounting by the Ministry of Agriculture. Since it was necessary to maintain consistency with the estimation on the supply side (the NSSO does not provide output estimates), it was decided to work with the basic magnitudes of per capita availability estimates, but ratios, rates, and elasticities derived from the 1977/78 NSS data were used in many parts of the estimation procedure. (See Appendix 8 for details.)

The starting point for each estimate was the national three-year average per capita availability of foodgrains (for human consumption) during 1982-1984, and this was disaggregated into rice, wheat, coarse cereals, and pulses. This was further broken down into rural and urban consumption levels. The procedure used rural-urban population ratios and differences between rural and urban per capita consumption of each grain represented by ratios obtained from the 1977/78 NSS results. Further, since consumption projections are based on disaggregated data by quartile, quartile shares are computed from the 1977/78 NSS survey data, and these are used to arrive at the per capita consumption level in each quartile for each major foodgrain in rural and urban areas. These starting levels are presented in Table 25.

The direct demand for foodgrains is considered to be driven primarily by population growth, income growth, and changes in income distribution. Estimates of past population growth are available from the population census conducted every 10 years, and projections for the year 2000 (which assume a slow decline in the population growth rate) are available in the Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2). Growth rates implicit in the Perspective Plan for rural and urban populations have been utilized in the projections. The rural and urban average per capita income (total expenditure) levels are available for 1970/71 from the 1970/71 NSS survey; similar figures are also available for 1983 from the 1983 NSS survey and were deflated to 1970/71 prices. However, the 1970/71-1983 growth rate in overall per capita incomes obtained from the above NSS figures were found to be too high (especially for the rural areas) relative to comparable figures obtained from national income data (India, Central Statistical Organization 1985) and the population census. Thus it was decided to use only the quartile per capita income shares from the 1983

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[16] The 5.5 million tons includes paddy seed expressed as paddy.

## Table 25—Per capita consumption of foodgrains: initial levels and shares

|  | 1982-84 per Capita Average | Quartile (Q) Share, 1977/78 National Sample Survey |  |  |  | 1982-84 Quartile Mean Consumption Level |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
|  | (kilograms/year) |  |  |  |  |  |  |  |  |
| Rural |  |  |  |  |  |  |  |  |  |
| Rice | 72.1 | 0.1729 | 0.2487 | 0.2824 | 0.2961 | 49.86 | 71.73 | 81.44 | 85.40 |
| Wheat | 47.8 | 0.1346 | 0.2070 | 0.2594 | 0.3991 | 25.74 | 39.58 | 49.60 | 76.31 |
| Coarse cereals | 40.3 | 0.2702 | 0.2512 | 0.2404 | 0.2382 | 43.56 | 40.49 | 38.75 | 38.40 |
| Pulses | 11.4 | 0.1210 | 0.2024 | 0.2672 | 0.4093 | 5.52 | 9.23 | 12.18 | 18.66 |
| Foodgrains | 171.7 | 0.1841 | 0.2359 | 0.2652 | 0.3147 | 124.67 | 161.03 | 181.98 | 218.77 |
| Urban |  |  |  |  |  |  |  |  |  |
| Rice | 55.5 | 0.2050 | 0.2566 | 0.2729 | 0.2655 | 45.51 | 56.97 | 60.58 | 58.94 |
| Wheat | 57.6 | 0.1875 | 0.2443 | 0.2732 | 0.2949 | 43.20 | 56.29 | 62.95 | 67.94 |
| Coarse cereals | 12.6 | 0.3891 | 0.2714 | 0.2087 | 0.1307 | 19.61 | 13.68 | 10.52 | 6.59 |
| Pulses | 12.2 | 0.1429 | 0.2169 | 0.2802 | 0.3600 | 6.97 | 10.52 | 13.67 | 17.57 |
| Foodgrains | 137.8 | 0.2115 | 0.2501 | 0.2672 | 0.2712 | 115.29 | 137.52 | 147.72 | 151.04 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics,* various issues (Delhi: Controller of Publications, various years).

NSS survey. The mean per capita income levels of the 1970/71 survey were moved to 1983 using per capita income growth rates based on national accounts (India, Central Statistical Organization 1985) and population figures. These were then distributed into quartile per capita income levels using shares obtained from the 1983 NSS survey.

Consumption scenario 1 assumed the continuation of past per capita income growth rates. Per capita income growth rates from 1970/71 to 1983 based on national accounts and population figures were used as the past per capita income growth rates. These were 0.49 percent a year for rural and 1.03 percent a year for urban areas (Table 26). Scenario 2 assumed the income growth rates of the perspective to 2000 in the Seventh Five-Year Plan of the Government of India. The plan projects an agricultural (assumed equivalent to rural income) growth rate of 2.50 percent, and an income growth rate for the total economy of 5.00 percent from the mid-1980s to 2000. Using midperiod sectoral weights, one can infer a nonagricultural (assumed equivalent to urban income) growth rate of 6.20 percent. The rural and urban populations are expected to grow at 1.15 and 3.63 percent, respectively (the rural, urban, and total populations are expected to reach 657, 319, and 976 million, respectively, by year 2000). This gives rural and urban per capita income growth rates of 1.33 and 2.48 percent. Scenario 3 assumes an increase in the income growth rates with the rural income growth rate rising to 3.00 percent and the urban to 7.00 percent, giving an overall income growth rate of 5.68 percent. Scenario 4 assumes a further acceleration of income growth rates to 3.50 percent for rural and 8.00 percent for urban areas. The latter is based on the observation that the industrial growth rate was close to 9.00 percent for three consecutive years prior to the 1987/88 drought and is expected to exceed 9.00 percent in 1988/89. In scenarios 3 and 4 it is assumed that nonfoodgrain agriculture in the rural areas, particularly the more labor-intensive and less land-using commodities, will grow at a faster rate than foodgrain agriculture. Scenario 4 implies a growth rate of 7.00 percent for the whole economy.

Alternative scenarios were also developed with regard to income distribution. The quartile income distribution from the 1983 NSS survey works out to 12, 18, 25, and 44

## Table 26—Alternative growth rate assumptions used in the simulations

| Scenario/Group | Income[a] | Population[b] | Per Capita Income |
|---|---|---|---|
| | | (percent) | |
| Base period | | | |
| Rural | 2.31 | 1.81 | 0.49 |
| Urban | 4.95 | 3.88 | 1.03 |
| Total | 3.86 | 2.26 | 1.56 |
| 1. Continuation of past per capita income growth rates | | | |
| Rural | 1.65 | 1.15 | 0.49 |
| Urban | 4.70 | 3.63 | 1.03 |
| Total | 3.43 | 1.84 | 1.56 |
| 2. Growth rates envisaged in the Perspective Plan[c] | | | |
| Rural | 2.50 | 1.15 | 1.33 |
| Urban | 6.20 | 3.63 | 2.48 |
| Total | 5.00 | 1.84 | 3.10 |
| 3. First accelerated growth rate scenario | | | |
| Rural | 3.00 | 1.15 | 1.86 |
| Urban | 7.00 | 3.63 | 3.25 |
| Total | 5.68 | 1.84 | 3.77 |
| 4. Second accelerated growth rate scenario | | | |
| Rural | 3.50 | 1.15 | 2.32 |
| Urban | 8.00 | 3.63 | 4.22 |
| Total | 7.00 | 1.84 | 5.07 |

Sources: Based on authors' calculations; see Appendix 8 for details and sources of data.

[a] The income growth rates are for gross domestic product at factor cost.

[b] The past population growth rate is the rate between the 1971 and 1981 census figures. The future population growth rate is between the 1981 census figure and the Perspective Plan projected figure for March 2001 adjusted to midyear 2000.

[c] In Chapter 2 of the Seventh Five-Year Plan of the Government of India.

percent, respectively, for the 1st, 2nd, 3rd, and 4th quartiles in the rural areas, and to 11, 17, 24, and 48 percent for those quartiles in the urban areas. If between 1983 and 2000 the income distribution does not change, then these shares will stay the same in 2000. It is implicit in this assumption that per capita income levels in each quartile will grow at the same rate, that is, at one overall income growth rate. Under an alternative assumption it is considered that there is a small improvement in the income distribution in the economy: the quartile shares change to 15, 20, 25, and 40 percent by the year 2000 in both the rural and urban areas. This implies that the per capita incomes of different quartiles grow at different rates—in particular, the incomes in the lower quartiles grow at a somewhat faster rate than the incomes in the higher quartiles. The initial and final quartile income levels and the required income growth rates for the different assumptions of income growth with change in income distribution are shown in Table 27. Given that the income elasticities of demand for foodgrains are higher in the lower quartiles, these differences lead to a higher overall demand for foodgrains—the effect of the change in income distribution. The gains from a change in income distribution are, however, dampened as elasticities fall with a rise in incomes. This aspect will be discussed later.

IFPRI has stressed that a major objective of global development should be the alleviation of the bulk of world poverty and hunger by the year 2000 (see Mellor 1989). The elimination of poverty by 2000 is also an objective set by the Planning Commis-

## Table 27—Per capita income growth rates and income levels under change in income distribution from 1983 to 2000, by quartile

| Item | Rural Income Quartile |  |  |  | Urban Income Quartile |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Initial income distribution (percent) | 12.00 | 18.00 | 25.00 | 44.00 | 11.00 | 17.00 | 24.00 | 48.00 |
| Initial income level (Rs/month) | 17.00 | 25.71 | 35.10 | 62.77 | 27.85 | 42.71 | 59.70 | 118.21 |
| Final income distribution (percent) | 15.00 | 20.00 | 25.00 | 40.00 | 15.00 | 20.00 | 25.00 | 40.00 |
| Under past per capita growth rates |  |  |  |  |  |  |  |  |
| Growth rate (percent) | 1.77 | 1.02 | 0.50 | −0.16 | 2.78 | 1.93 | 1.27 | 0.00 |
| Income (Rs/month) | 22.91 | 30.55 | 38.19 | 61.11 | 44.36 | 59.15 | 73.93 | 118.29 |
| Under Seventh Plan growth rates[a] |  |  |  |  |  |  |  |  |
| Growth rate (percent) | 2.62 | 1.86 | 1.34 | 0.68 | 4.25 | 3.40 | 2.72 | 1.44 |
| Income (Rs/month) | 26.40 | 35.20 | 44.00 | 70.39 | 56.52 | 75.36 | 94.20 | 150.72 |
| Under first accelerated growth rate scenario[b] |  |  |  |  |  |  |  |  |
| Growth rate (percent) | 3.16 | 2.40 | 1.87 | 1.20 | 5.03 | 4.17 | 3.49 | 2.20 |
| Income (Rs/month) | 28.85 | 38.46 | 48.08 | 76.92 | 64.69 | 85.59 | 106.98 | 171.17 |
| Under second accelerated growth rate scenario[b] |  |  |  |  |  |  |  |  |
| Growth rate (percent) | 3.63 | 2.86 | 2.33 | 1.66 | 6.02 | 5.15 | 4.46 | 3.16 |
| Income (Rs/month) | 31.14 | 41.52 | 51.90 | 83.05 | 75.25 | 100.33 | 125.41 | 200.66 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics,* various issues (Delhi: Controller of Publications, various years).

Notes: No change in the distribution implies that all quartiles will grow at the same rate namely, the rate of growth of per capita income. All incomes are in constant 1970/71 prices. The initial income levels are for 1983 and the final figures are for year 2000.

[a] Refers to the Seventh Five-Year Plan of the Government of India.

[b] Growth rate assumptions are given in Table 26.

sion of India. It was of interest, therefore, to examine whether poverty would be substantially eliminated by 2000 under any of these scenarios. The most commonly accepted definition of the poverty line for India has been given by Dandekar and Rath (1971); this amounts to an income (consumer expenditure) level of Rs 15.00 a month in rural areas and Rs 22.50 a month in urban areas in 1960/61 prices. These levels are based on a daily minimum calorie intake level of 2,250 calories a person. Rural people obtain comparatively more calories from foodgrains than urban people, but urban people pay more per calorie. Most later studies, including those of Ahluwalia (1978, 3-41) and Mellor and Desai (1985), use the consumer-expenditure-based standards of the poverty line set by Dandekar and Rath. On moving consumer expenditures to 1970/71 prices (the base used in this study), using the agricultural laborers' consumer price index for rural and the industrial workers' consumer price index for urban expenditures, the poverty line works out to an income (total expenditure) level of Rs 28.80 a month for rural and Rs 41.25 for urban in 1970/71 prices (the former figure has been confirmed by Ahluwalia [1978]). Therefore, one way to examine whether poverty has been nearly eliminated would be to see whether the income level of each quartile has crossed the above-mentioned poverty line levels. This will be examined and discussed with the projection results. (There may be bottom-end poverty left in the bottom quartile even when its average income crosses the poverty line. The Perspective Plan aims for elimination of poverty but actually targets reduction in poverty to 5 percent.)

With respect to the income elasticities of demand, it was found that the log-log inverse function, which is frequently used for estimating elasticities from consumer survey data, provided in general a poor fit for the foodgrain consumption data of the 1977/78 NSS survey. Further, when quartile elasticities were computed from the function, they tended to be too low for the bottom quartile and too high for the top quartile. This is due to the shape restrictions of the curve and because a single curve was fitted to the entire data. The NSS data, however, permit the estimation of elasticities (by log-log function) for each quartile (Table 28), and these estimates appeared to be, in general, more reasonable.

The estimates show that the elasticities are greater than 1 for the bottom quartile, and close to zero for the top quartile. The elasticity estimate of 3.25 for wheat for the urban bottom quartile is probably a result of some specific data problems for wheat in this survey (this estimate is not used directly, as explained below). The elasticity for coarse cereals is shown to be high (of the order of 1.5) for the bottom quartile, whereas the elasticity for pulses was found to be still quite high in the top quartile. Given the long period of 17 years across which projections were to be made, it was inappropriate to assume that these elasticities would hold constant. As incomes rise, the elasticities would fall. This is evident from the interquartile differences in the elasticities. Therefore, the above figures were not used directly. It was assumed that the elasticities would fall along a log-log function path, and the path was estimated by using the quartile elasticities. Elasticities were stepped down in four steps for each of the periods 1983-85, 1985-90, 1990-95, and 1995-2000, and these elasticity matrices were used for the projection work. Each set of growth rates and income distribution assumptions

## Table 28—Income elasticities of demand, by foodgrain and quartile

| | | | | | Sample of Step Elasticity Matrix (1990-95) Used for Simulation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated within Each Quartile by Log-Log, Using National Sample Survey 1977/78 Data | | | | Under Past per Capita Income Growth Rates and No Change in Distribution | | | | Under Second Accelerated Growth Rate Scenario with Change in Income Distribution | | | |
| Foodgrain | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Rural | | | | | | | | | | | | |
| Rice | 1.02 | 0.59 | 0.28 | 0.09 | 0.93 | 0.58 | 0.36 | 0.03 | 0.68 | 0.42 | 0.26 | −0.02 |
| Wheat | 1.37 | 0.74 | 0.81 | 0.41 | 1.23 | 0.92 | 0.71 | 0.39 | 1.01 | 0.77 | 0.61 | 0.33 |
| Coarse cereals | 1.46 | −0.09 | −0.16 | 0.00 | 0.68 | 0.30 | 0.08 | −0.24 | 0.41 | 0.14 | −0.03 | −0.29 |
| Pulses | 1.27 | 1.05 | 0.90 | 0.38 | 1.34 | 1.00 | 0.78 | 0.42 | 1.09 | 0.84 | 0.66 | 0.36 |
| All foodgrains | 1.24 | 0.47 | 0.35 | 0.20 | 0.98 | 0.64 | 0.44 | 0.10 | 0.74 | 0.49 | 0.32 | 0.05 |
| Urban | | | | | | | | | | | | |
| Rice | 0.95 | 0.28 | 0.04 | 0.00 | 0.52 | 0.26 | 0.08 | −0.20 | 0.24 | 0.06 | −0.06 | −0.27 |
| Wheat | 3.25 | 0.28 | 0.26 | 0.10 | 1.39 | 0.69 | 0.28 | −0.27 | 0.64 | 0.24 | −0.01 | −0.38 |
| Coarse cereals | 1.61 | −0.65 | −0.95 | −0.11 | −0.38 | −0.54 | −0.64 | −0.78 | −0.55 | −0.65 | −0.71 | −0.81 |
| Pulses | 1.53 | 0.80 | 0.58 | 0.20 | 1.14 | 0.73 | 0.47 | 0.04 | 0.71 | 0.43 | 0.25 | −0.06 |
| All foodgrains | 1.35 | 0.22 | 0.07 | 0.06 | 0.68 | 0.36 | 0.15 | −0.18 | 0.34 | 0.12 | −0.02 | −0.26 |

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, Round 32 (1977/78) (New Delhi: NSSO, 1984); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

therefore gave a different set of elasticity matrices for projection. A sample of two such matrices is presented in Table 28 for rural and urban areas.

Bouis and Haddad (1989), on the basis of consumption survey data from Bukidnon Province of the Philippines, have indicated that the elasticity estimates obtained vary with the kind of data used for estimation, and there would be a tendency for them to be somewhat higher when estimated on the basis of consumer expenditure survey data. This could not be tested in the case of the Indian data, but high elasticity estimates for the bottom quartile seem reasonable given the extreme hunger and poverty in India, and the elasticity estimates for the top quartile are in any case very low. The projection procedure also steps down the elasticities as incomes increase over time.

Apart from the foodgrain demand for direct human consumption, an increasingly important component is the indirect demand for feedgrains through livestock consumption. Unfortunately, an elaborate projection of this demand cannot be made because of inadequate and poor data; in particular, income distribution effects cannot be worked out. For details of the procedure followed, see "Projections of Requirements for Seed, Feed, Industrial Use, and Wastage" in Appendix 8. The procedure works with livestock output units that equal the weight of meat plus the weight of eggs plus one-tenth the weight of milk. Even in these terms, milk dominates the livestock output/demand in India with a share of 70 percent, followed by meat and then eggs. It is assumed that the demand for livestock products is driven by income growth, through an income elasticity of demand of 0.9. This is an output weighted average across different livestock products for India and is derived from Sarma (1986); it is close to a broad FAO estimate provided by Paulino (1986). The relationship between livestock demand and feedgrain demand expressed in terms of the average feeding ratio (kilograms of feedgrain to kilograms of livestock output measured in livestock output units) was estimated to be 2.0 for India in 1984/85. This level reflects a largely rural livestock sector feeding large amounts of crop residues. Mellor and Ponteves (1964) have shown that the ratio is likely to rise substantially with increasing demand for livestock products, particularly as crop residues become inadequate and more productive livestock require better feeding. It is assumed that the average feeding ratio would rise at a rate of 1.2 percent a year to reach about 2.4 by the year 2000, which is equal to the current developing-country average and compares with 3.2 for the world and 2.6 for Asian developing countries. Based on these ratios, the feedgrain demand in the year 2000 is estimated to be about 22 million tons under continuation of past per capita income growth rates, 27 million tons under Perspective Plan income growth rates, 29 million tons under the first accelerated growth rate scenario, and 35 million tons under the second accelerated growth rate scenario. The range between the feedgrain demand outcomes of 22 million tons and 35 million tons is large and can make a significant difference in the foodgrain situation of the country. Such scenarios would be likely to come about sooner or later with the acceleration of economic growth, and they have been observed in several other developing countries. Apart from feed, the seed demand works out to about 5 million tons and other uses and wastage to about 12 million tons. (See Appendix 8 for details.)

The results of total estimated foodgrain demand under the different scenarios—continuation of past per capita income growth rates, Seventh Plan/Perspective Plan income growth rates, first accelerated growth rate scenario, and second accelerated growth rate scenario, with and without income distribution change, are summarized in Table 29. The results show that substantially different outcomes of demand can emerge under these different future scenarios. The direct foodgrain demand can vary from 167 million tons to as much as 189 million tons. The total foodgrain demand (incorporating

## Table 29—Projected total demand for foodgrains in India in year 2000

| Consumption Scenario for Alternative Income Growth Rate Assumptions | Alternative Income Distribution Assumptions | | | |
|---|---|---|---|---|
| | Without Change in Income Distribution (1983-2000)[a] | | With Change in Income Distribution (by 2000)[b] | |
| | Human Demand | Total Demand[c] | Human Demand | Total Demand[c] |
| | (million metric tons) | | | |
| 1. Continuation of past per capita income growth rates | | | | |
| Rural | 121.06 | . . . | 126.53 | . . . |
| Urban | 46.02 | . . . | 49.01 | . . . |
| Total | 167.08 | 206.35 | 175.54 | 214.81 |
| 2. Growth rates envisaged in the Perspective Plan | | | | |
| Rural | 127.82 | . . . | 133.13 | . . . |
| Urban | 47.68 | . . . | 49.99 | . . . |
| Total | 175.51 | 219.70 | 183.11 | 227.30 |
| 3. First accelerated growth rate scenario | | | | |
| Rural | 131.69 | . . . | 136.83 | . . . |
| Urban | 47.97 | . . . | 49.82 | . . . |
| Total | 179.66 | 226.30 | 186.65 | 233.29 |
| 4. Second accelerated growth rate scenario | | | | |
| Rural | 134.78 | . . . | 139.73 | . . . |
| Urban | 47.76 | . . . | 49.01 | . . . |
| Total | 182.54 | 234.54 | 188.74 | 240.74 |

Notes: Foodgrains include cereals and pulses; rice is expressed in terms of milled rice. Parts may not add to totals because of rounding.

[a] Shares in percentages ($Q_1/Q_2/Q_3/Q_4$); rural—12/18/25/45, urban—11/17/24/48. $Q_1$, $Q_2$, $Q_3$, and $Q_4$ represent quartile shares of income based on the National Sample Survey consumer expenditure data for 1983.

[b] Shares in percentages ($Q_1/Q_2/Q_3/Q_4$); both rural and urban—15/20/25/40.

[c] Includes allowance for seed, feed, other uses, and wastage. The estimated feed demand takes into account the effect of income growth only, not of changes in its distribution.

feed, seed, industrial use, and wastage) can vary from 206 million tons to as much as 240 million tons. Acceleration of income growth rates adds up to 28 million tons for the demand, and the assumed change in income distribution totals 6 million tons.

With regard to poverty alleviation, it is found that consumer expenditure (income) levels cross the poverty line for all the quartiles only under the first and second accelerated growth rate scenarios, and in both cases only when accompanied by a change in income distribution. In none of the other scenarios is poverty alleviated (see also Table 27). This shows that a combination of acceleration in growth rates and at least a moderate change in income distribution will be required to alleviate poverty by the year 2000—neither of these alone may be sufficient. And further, this will have substantial implications for foodgrain demand. In this context, given the above observations relating the scenarios to poverty alleviation, and with the national objectives of acceleration of economic growth and alleviation of poverty, it may be stressed that *a foodgrain consumption level of about 233 million tons by the year 2000 might be considered a target.*

The demand estimates, when compared with the foodgrain production projections given earlier, show outcomes ranging from the emergence of a marginal self-sufficiency or a surplus of 13 million tons to a deficit of 20-30 million tons. These outcomes have profound implications for various scenarios for India's development (see Table 30). They show that if the twin objectives of acceleration in economic growth and alleviation of poverty set by the Indian planners are to be realized, there will be tremendous pressure on foodgrain supplies. This will call first for unrelenting efforts to raise foodgrain production. Moreover, this will need to be done with increased efficiency if it is to be economical, generate growth in real farm incomes, and avoid large government subsidies. However, the estimates show that even impressive performance on production may prove inadequate to meet the demand. This may call for political courage to import foodgrains on a sizable scale and would require a development strategy that can pay for the foodgrain imports by generating export surpluses in other goods. Therefore, faster economic growth and eradication of poverty might not be feasible without sizable imports, notwithstanding even an impressive growth in foodgrain production from current levels to 220 million tons by the year 2000.

Mellor (1978) and Ezekiel (1990) have shown that if demand is allowed to outstrip supply and food prices rise, the burden of adjustment falls mainly on the poor, since they have relatively high income elasticities of demand and high budget shares of income spent on food. This may be undesirable. In the context of the appropriate development strategy, Desai and Schluter (1974) have shown that even marginal changes in the cropping pattern can help generate more employment in the rural areas. Further, Islam (1990) has shown that nontraditional agricultural exports could play an important role in generating the necessary export surpluses while also helping rural income and employment growth. Model simulations by Mellor and Mudahar (1974) have shown that the nonfoodgrain agriculture sector appears to have a large potential for employment and that the importance of this employment may increase as industrialization takes place. Changes in the cropping pattern and an acceleration in the

**Table 30—Projected foodgrain supply-demand balances under alternative scenarios of production and consumption projections in year 2000**

| Consumption Scenario | Total Demand | Production Scenario (1) 219.4 Million Metric Tons[a] | (2) 210.7 Million Metric Tons[b] | (3) 215.2 Million Metric Tons[c] |
|---|---|---|---|---|
| | | (million metric tons) | | |
| 1. Continuation of past per capita income growth rate | 206.4[d] | + 13.0 | + 4.3 | + 8.8 |
| | 214.8[e] | + 4.6 | −4.1 | + 0.4 |
| 2. Growth rates envisaged in the Perspective Plan[f] | 219.7[d] | −0.3 | −9.0 | −4.5 |
| | 227.3[e] | −7.9 | −16.6 | −12.1 |
| 3. First accelerated growth rate scenario | 226.3[d] | −6.9 | −15.6 | −11.1 |
| | 233.3[e] | −13.9 | −22.6 | −18.1 |
| 4. Second accelerated growth rate scenario | 234.5[d] | −15.1 | −23.8 | −19.3 |
| | 240.7[e] | −21.3 | −30.0 | −25.5 |

Sources: Based on Tables 23 and 29.

[a] Production scenario 1 is based on each crop area and yield projected separately for each region.

[b] Production scenario 2 is based on total foodgrain area and yield projected in each region.

[c] Production scenario 3 is based on total foodgrain area and yield projected at the all India level.

[d] Consumption scenario without change in income distribution (1983-2000), given the following existing percent income shares for the different quartiles: $Q_1/Q_2/Q_3/Q_4$; rural—12/18/25/45, urban—11/17/24/48.

[e] Consumption scenario with change in income distribution (by 2000) to the following percent income shares for the different quartiles: $Q_1/Q_2/Q_3/Q_4$; both rural and urban—15/20/25/40.

[f] From the Seventh Five-Year Plan of the Government of India.

nonfoodgrain rural sector through activities such as production of livestock and nontraditional agricultural goods would be crucial for accelerating rural income growth, particularly beyond the limits of growth in foodgrain production. This may become critical for meeting the twin overall objectives of acceleration in economic growth and alleviation of poverty.

The breakup by commodity of the demand-supply balances is given in Table 31 for the demand scenario of the Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) growth rates without change in income distribution. Attention was drawn earlier to the caution necessary in interpreting the breakup by commodity of projected foodgrain production in 2000. Subject to these cautions, Table 31 shows that, whereas rice demand is almost squarely met by production, a significant surplus of 11 million tons emerges for wheat under the assumptions of this scenario. A substantial deficit of 11 million tons emerges for coarse cereals. This deficit appears mainly because of the projected rise in feedgrain demand as well as the projected decline in the coarse cereals area due to downward regional trend lines and the area normalization procedure. Therefore, such a deficit may or may not emerge, but if it does it would tend to bid up the relative prices of coarse cereals. This may affect the food consumption of the poor, especially the rural poor, who depend on coarse cereals to a larger extent. At the same time, high coarse cereal prices may tend to suppress the growth of the livestock industry, which may be otherwise beneficial from the point of view of employment and income growth. This may raise complex questions about the comparative advantage of producing coarse cereals for livestock feed in India versus importing it at a possibly lower relative price to help the livestock industry and perhaps generate more employment.

Pulses show a deficit of 3 million tons, which may be met by diversion of more area to pulses or by import of substitutes, as sometimes seen in past imports of Australian chickpeas. In general, these imbalances in individual commodities may be expected to be resolved through market mechanisms, either in a closed or an open economy framework. These mechanisms may lead either to a change in production and consumption patterns or to the export of one commodity and the import of another. Wheat may partly substitute for coarse grains, both in food and feed; pulses may rebound in production because of high market prices.

Table 32 provides a comparison between the scenario results in this study and the projections of other studies. It shows that the production projections of this study are lower than those of the Seventh Five-Year Plan but higher than those of the World

**Table 31—Comparison of foodgrain production and demand projections for year 2000**

| Foodgrain | Production | Demand | Difference |
|---|---|---|---|
| | | (million metric tons) | |
| Rice | 84.7 | 82.0 | 2.7 |
| Wheat | 86.7 | 75.0 | 11.7 |
| Coarse grains | 34.5 | 46.2 | -11.7 |
| Pulses | 13.5 | 16.5 | -3.0 |
| Total foodgrains | 219.4[a] | 219.7[b] | -0.3 |

[a] From production scenario 1 (see Table 30).

[b] From consumption scenario 2 (see Table 30) with no change in income distribution.

### Table 32—Comparison with foodgrain production and consumption projections to year 2000 by other studies

| Study | Production | Consumption |
|---|---|---|
| | (million metric tons) | |
| National Commission on Agriculture, India, 1976 | 230.0 | 225.0 (high)<br>205.0 (low) |
| World Bank, 1981 | 213.0 (high)<br>197.0 (low) | 205.0 (high)<br>191.0 (low) |
| Seventh Five-Year Plan, 1985-90, Planning Commission | 235.0-240.0 | 240.0 |
| Present study | 219.4 (high)[a]<br>210.7 (low)[c] | 240.74 (high)[b]<br>206.35 (low)[d] |
| IFPRI study (for the Asian Development Bank), 1984 | 220.74 | 210.23 |

[a] Based on production scenario 1 (see Table 30).

[b] Based on the second accelerated growth rate consumption scenario with change in income distribution.

[c] Based on production scenario 2 (see Table 30).

[d] Based on continuation of past per capita income growth rate consumption scenario with no change in income distribution.

Bank. The Seventh Plan consumption target of 240 million tons in 2000 matches closely the estimates of this study under accelerated economic growth with a small change in income distribution. As stated earlier, this scenario would result in the alleviation of poverty. However, the Seventh Plan's production projections appear high, since they imply a production growth rate of up to 3.4 percent compared with 2.6 percent in the past, and, as was analyzed earlier, even the achievement of 220 million tons appears to be a difficult task. Achievement of the necessary rural income growth rates to reach poverty alleviation and the target consumption would also require rapid growth in nonfoodgrain agriculture.

The foodgrain production in 2000 estimated by the National Commission on Agriculture at 230 million tons is higher than the present study's estimate of 219 million tons in production scenario 1. However, since the two projections started with different base periods, the implicit growth rates actually work out to be the same. The commission assumed a higher fertilizer response coefficient (10 tons/ton), so despite a higher production projection, the commission estimated lower fertilizer requirements of 14-16 million tons by 2000. Analysis in this study has, however, shown that the response coefficient has declined to about 7, indicating that apart from the need for more fertilizers (estimated at 20 million tons), there would be increased difficulty in reaching even 220 million tons of foodgrain production.

IFPRI (1984) also attempted to project the supply-demand balances of foodgrains for member countries of the Asian Development Bank. The production estimates obtained in it for India are similar to those under the present study, but the high consumption estimates of this study are considerably higher. In particular, the other studies do not bring out the markedly different demand-supply scenarios that are likely to emerge for foodgrains in India under alternative scenarios of development, particularly when the twin objectives of acceleration in economic growth and eradication of poverty are pursued. These differences stem substantially from an increased demand for food as incomes grow and poverty is alleviated, and from an increased demand for feedgrains as the demand for livestock products increases.

## 7

# CONCLUSIONS AND POLICY IMPLICATIONS

India has accomplished an impressive transformation in its agricultural sector, particularly in foodgrains, over the past 25 years. Study of the country's foodgrain production and consumption shows substantial growth in production and considerable change in various factors underlying that growth. However, the levels and patterns of consumption on a per capita basis show relatively less improvement. In the coming decades the foodgrain situation may still change significantly, and growth in consumption may play a very important role. Future development will, however, depend substantially on the objectives, priorities, and strategy of government policies. The results and discussions in this study provide a number of findings that may be of considerable importance for these decisions and policies.

## Sustaining Growth in National Foodgrain Production

In the late 1970s and early 1980s, a number of studies raised concerns about a possible deceleration in the growth of foodgrain production, indicating a decline in the momentum of the green revolution and possible exhaustion of the potential of available technology. Analyzing a longer national time series, the present study finds that there was, in fact, some deceleration from the pre-green-revolution period (1949/50-1964/65) to the first half of the green-revolution period (1967/68-1975/76), coming substantially from a decline in the area growth rate. But the study also finds evidence of an acceleration of the growth rate, from 1.9 to 2.4 percent a year, from the first to the second half (1975/76-1983/84) of the green-revolution period. This appears to have been driven, in particular, by a geographic spread in the yield growth that led to a more broad-based growth in foodgrain production. This has, however, still left out several potential growth regions such as the Eastern region.

This acceleration raises the hope of sustaining the national growth in foodgrain production. Other evidence, however, indicates that as much as 90 percent of the growth in the second half of the green-revolution period came from yield growth and that this growth was almost entirely technology-based, involving substantial increases in the adoption and use of modern inputs by the farmers. This shows that future growth in foodgrain production is likely to be critically dependent on a rapid pace of technological change. In this process, increasing the use of modern inputs and maintaining their productivities would be crucial. Thus, even though there has been acceleration in the recent past, the study indicates that any future growth in foodgrain production would be extremely demanding, and a substantial government commitment to technology-based growth in agriculture would be exceedingly important.

## Regional Patterns in Production Growth

Analysis of regional patterns of growth indicated that in past decades, growth in foodgrain production had been relatively concentrated, particularly in the Northern region. This was partly related to natural endowments, preexisting infrastructure, suitability of seed-fertilizer technology breakthroughs, and concentration of government efforts in this region to raise food production rapidly. All these factors led to a predominance of the Northern region in growth, and also to concerns about the country's substantial dependence on it and doubts about whether other regions could generate such growth. This predominance may also have contributed to difficulties in sustaining and accelerating the growth adequately and in improving the cost-efficiency of the growth.

The analysis in this study shows that the growth in 1975/76-1983/84 had better geographic distribution, with the Uttar Pradesh and Central regions in particular joining in more rapid growth. This change in pattern helped to reduce the concentration of growth and dispel doubts about the potential for growth in other regions. It showed that more broad-based growth was possible and, given its many benefits, should be planned for. Further progress in this direction would imply, in particular, the inclusion of the Eastern and Western regions in growth through the diffusion and adoption of better technologies.

Inclusion of the Eastern region would be critical to making a significant dent in elimination of national poverty, because of the concentration of poverty and potential for growth there. Rapid growth in the Eastern region would require concerted efforts to tackle its special problems of development. The Committee on Agricultural Productivity in Eastern India (Sen Committee) has indicated that this would require large-scale investment in infrastructure as well as emphasis on improving the administration and management of development programs. Accelerating growth in the Western region would call for special efforts to improve the productivity and stability of dryland crops through new varieties, better water management, and tackling of the specific soil fertility constraints there. Declining production growth in the Southern region is also of concern but is found to be mainly due to the declining area allocated to foodgrains. The nature, causes, and relative benefits of this diversion may require further investigation.

## Inputs: Growth in Use and Decline in Productivities

Observations on growth rates indicates the large and increasing importance of yield growth in raising production in the green-revolution period. Further, decomposition of the yield increase into components of cropping pattern change and pure yield effects shows that the bulk of the increase in overall yields on an all-India basis came from the pure increases in crop yields. This implies the substantial importance of technological change associated with large increases in input use. A study of the input use data shows that there is a large growth in modern input use in the recent past, particularly of HYV area and fertilizer use. The use of these continues to be concentrated but seems to have extended beyond the relatively slow-growing irrigated area.

A major problem indicated by the analysis, however, is a decline in aggregate input productivities. This is shown for fertilizers but in every likelihood involves the other inputs as well (the decomposition is difficult because of problems in separating effects and because of multicollinearity). The decline in productivities implies that large increases in input use will be required to generate the necessary growth in production. The reasons behind this decline urgently require further investigation and research. The decline could be partly a result of diminishing returns due to persistent concentration of input use in certain areas. Overcoming this will require policy changes toward the diffusion of input use to other areas where the gains obtainable in additional production may be higher. In areas of current concentration, efforts may be required to break out of the diminishing returns, possibly through more balanced application of nutrients, application of organic manures, and more careful management of soil fertility and other factors of production including water management. Another reason for the decline in productivities may be the spread of fertilizer use to rainfed and dryland areas and to coarse grains where productivities may currently be low. This will require further work in developing productive and resilient varieties for these areas, better water management, and a clearer understanding of the soil fertility and nutrient constraints in these locations.

## Growth and Patterns in per Capita Consumption

An examination of trends in the levels of per capita availability of foodgrains showed no statistically significant long-term improvement or decline. This was puzzling, particularly because the long-term growth in foodgrain production was fairly impressive at 2.6 percent a year and was higher than the population growth rate of 2.2 percent. It seems that the difference was utilized primarily to reduce foodgrain imports and build up stocks. There was little growth in the per capita consumption of foodgrains, despite national income growth on the one hand and persistent hunger on the other. Among the reasons for the slow growth in demand appear to be the weak linkage effects from the growth in foodgrain production, and the failure of the development strategy to significantly improve the incomes of the poor. Since the incomes of those in the bottom quartile, who have relatively high elasticities of foodgrain demand, have not grown rapidly, this has affected the growth in foodgrain demand. This calls for an enhanced focus on poverty alleviation through improving growth linkages of the existing productive activities (through better infrastructure and services), encouraging growth in potential areas where the poor are concentrated (for example, the Eastern region), and fostering labor-intensive productive activities (including forms of livestock and horticulture production).

The National Sample Survey data on per capita total consumer expenditure (in real terms, used as a proxy for real income per capita) confirm the above-mentioned patterns in income distribution. The data further indicate that between 1977/78 and 1983 the total expenditure disparity between the top and bottom quartiles in the rural areas lessened somewhat, and the disparity between rural and urban areas also appears to have been reduced. This may indicate slight movement toward an improved income distribution that may continue into the future. Between 1970/71 and 1983 the income in the rural bottom quartile shows a small increase, but the urban bottom quartile income shows very little change, perhaps reflecting relatively good agricultural performance but inadequate nonagricultural growth. This situation draws attention to the urgent need to address persistent urban poverty, but there is an equally urgent need to tackle poverty in rural areas, where the numbers are much larger and the income levels still extremely low.

The National Sample Survey per capita foodgrain consumption data show a small decline of 6.4 kilograms or 3.4 percent in annual per capita foodgrain consumption between the 1970/71 and 1983 surveys. An equivalent trend is, however, not shown by the per capita availability data. Given that the consumption survey covers one year in several years, this decline might be a reflection of year-to-year fluctuations. The decline is shown by both the urban and rural data and is intriguing because the real per capita incomes, particularly in the rural areas, show a small rise between these years. One answer may lie in the relative price movements. On examination of these movements for cereals the results show that the real prices of cereals, when based on the national wholesale price indices, declined between 1970/71 and 1983, but when based on implicit consumer prices, the real prices did not decline as much. And particularly in the rural areas the real consumer prices increased, and increased relatively more for the bottom quartile. This indicates that part of the benefits of income growth, especially to the poor in the rural areas, were neutralized by adverse movement of prices. The above finding indicates that under development with inflation, in order to maintain and improve the nutritional status of the poor, their incomes may need to grow faster than usually assumed so as to counteract adverse price effects. It also shows that past growth in foodgrain demand may have been constrained not only because of slow growth in the incomes of the poor but also to some extent because of adverse movement of prices for the rural poor.

## Future Growth in Production

Even though doubts about a deceleration might be put aside for the time being, it is evident from the study that sustaining future growth in production is likely to be an extremely difficult task. This is apparent from, among other things, the sharp increase in the importance of yield growth, little recent change in the absolute potential of basic biochemical technology, the decline in input productivities, and the relative geographic concentration of growth. Future production growth will require continued substantial emphasis by the government on technology-based growth in agriculture along all these fronts.

The future scenario with the level of production projected for the year 2000 at 219 million tons (base) envisages a growth of 2.8 percent a year in the total output, and of this, 96 percent needs to come from increases in yield—from an average of 1,060 kilograms per hectare in 1983/84 to 1,627 kilograms in 2000. The other two production scenarios imply growth rates of 2.7 percent and 2.6 percent over the trend base of 140 million tons in 1983/84. The input requirements for achieving the base scenario level of production indicate an annual increase of about 6.0 percent in fertilizer consumption and 3.9 percent in gross irrigated area under all crops. For fertilizers this involves, on average, an increment of 750,000 tons of fertilizer (NPK) every year, which is almost double the past annual increases between 1967/68 and 1983/84. This increment will require, among other things, wider geographic distribution of fertilizer use and its more intensive and balanced use in some areas. This may call for tremendous efforts in several directions such as development of knowledge on the appropriate fertilizer use on different locations and crops and dissemination of that information; institutional arrangements and services for the supply of fertilizers on time in the required quantities and type; provision of credit for fertilizer purchase; and favorable input/output pricing policies.

The level of irrigated area assumed in the base scenario (100 million hectares) calls for an annual increase of 2.9 million hectares between 1983/84 and 2000 in the actual utilization of irrigation. This is nearly double the annual increase achieved between 1967/68 and 1983/84. The Seventh Five-Year Plan assumes an addition of 2.2 million hectares under irrigation each year, and this needs to be stepped up in subsequent plans, particularly because the potential created is frequently not fully utilized. Data given in Chapter 4 indicate that average yields of at least 3 tons per hectare of wheat and rice can be realized on irrigated areas if HYVs, fertilizers, and improved agricultural practices are adopted simultaneously.

The production growth envisaged in this study also requires an acceleration of growth in the Eastern region, which will require substantial emphasis on the development of this region. The Committee on Agricultural Productivity in Eastern India has indicated that this will require large investments in infrastructure and improvement of rural services as well as location-specific research to better exploit the potential of this region.

## Future Growth in Direct Human Consumption Demand

The study finds that the low-income groups have relatively low levels of foodgrain consumption as well as high income elasticities of foodgrain demand. Improvement in their incomes, through growth and better income distribution, is extremely important for alleviation of poverty and hunger but will lead to faster growth in the demand for foodgrains.

Under a consumption scenario that assumes Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) income growth rates and no change in income distribution, direct human consumption in 2000 is expected to reach about 176 million tons, which amounts to about 180.0 kilograms per capita per year compared with 166.6 kilograms in 1982-84, assuming unchanged relative prices. Two-thirds of this increase may be attributed to population growth and one-third to income growth. Under an accelerated growth rate scenario that assumes an acceleration in income growth rates (to 3 percent rural and 7 percent urban, amounting to 5.7 percent national), with a small change in income distribution, direct human consumption is expected to reach 187 million tons in 2000. This amounts to about 191 kilograms per capita per year. This latter scenario would result in poverty alleviation by raising even the average income of the bottom quartile above the poverty line. Achieving this scenario, which may be considered a target, would require substantial efforts in raising growth in foodgrains, nonfoodgrains, and the nonagricultural sector in ways that generate more employment and incomes for the poor.

## Future Growth of Feed Demand

More rapid economic growth will also lead to faster growth in the demand for livestock products, particularly from the upper- and middle-income groups. This in turn is likely to lead to a rise in the demand for feedgrains. The feedgrain demand usually rises rapidly with economic growth in most developing countries, and its past growth rate in India has been relatively high. Future economic growth is likely to lead to a more buoyant demand for livestock products in India. This would result in a larger demand for livestock feed and would gradually lead to the exhaustion of by-products currently available for feeding animals, which would necessitate feeding more grains to the animals. The shift to rearing more productive animals would also create a need for better animal nutrition, thereby increasing the need to feed grains. All these factors may lead to an increase in the average feeding ratios of feedgrain input to livestock output, thus further accelerating feedgrain demand. Since livestock production can be substantially labor-intensive in developing countries, an expansion of the livestock sector could also contribute to generating employment and incomes for the poor.

## Production-Consumption Balances

Although the scenarios for production and consumption of foodgrains in 2000 may appear to have been worked out separately, they are in fact linked through the assumptions. The output levels of 211-219 million tons in 2000 imply growth rates of 2.6-2.8 percent over the trend output of 140 million tons in 1983/84. The rural income growth rates envisaged in the different consumption scenarios, however, range from 2.3 to 3.5 percent. The growth rates in use of inputs required to sustain a growth of 2.8 percent in foodgrain production are by themselves very large, and when further given the constraints to area growth, it becomes obvious that rapid growth in rural incomes may need to come significantly from outside the foodgrain sector. To achieve a rural income growth rate of 3.5 percent, nonfoodgrain agriculture would need to grow at a rate of over 4.0 percent. There appears to be potential for faster growth in nonfoodgrain activities in the rural areas, and the development strategy should focus on these activities, particularly those that are labor-intensive. Such a strategy may also improve the employment and income opportunities for the lower-income groups. Cultivation of high-value export-oriented crops, livestock production including the poultry and dairy sectors, and small-scale industries are possible labor-intensive activities with potential for rapid growth.

The regional pattern of growth within the foodgrain production projections also has important linkages with the consumption scenarios. An explicit assumption in the production projection is acceleration in production growth in the Eastern region. Given the relative concentration of poverty in this region, this acceleration of growth would be crucial for raising the incomes in the rural bottom quartile, thereby alleviating poverty as well as bringing growth in foodgrain demand. Similarly, achievement of the expected production growth performance in the Southern and Western regions would be important for raising the incomes of the poor. Such accomplishments would require specific policy emphasis toward the problems of agricultural growth in these regions.

The achievement of expected yield growth rates in wheat and rice in the Northern, Uttar Pradesh, and Central regions would also be required to bring about overall growth in production and rural incomes. This would demand continued government emphasis, particularly on research and extension in these regions.

## Implications of Faster Economic Growth and Poverty Alleviation

India's Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) aims to accelerate economic growth and eliminate poverty by 2000. Alleviation of poverty will require raising the incomes of the poor, particularly the bottom quartiles in both the rural and urban areas. This will require economic growth as well as better distribution of income. Growth in foodgrain production, given its importance, will need to be an important cornerstone of the development strategy. But meeting the government's objectives will also require accelerated growth in nonfoodgrain rural activities including nonfoodgrain crops, livestock, fisheries, social forestry, and rural industries. It will require greater emphasis and investment in an employment-oriented strategy of growth that can raise the incomes of the poor more rapidly. This analysis shows that a successful implementation of such a strategy, leading to acceleration of income growth rates and improvement in income distribution, could also lead to food demand growth that might make India deficit in foodgrains. This would create a need to import despite an impressive agricultural performance. On the other hand, a failure of the strategy might leave India marginally surplus in foodgrains.

Therefore, achieving the twin objectives of acceleration of economic growth and elimination of poverty will call for the adoption of an appropriate development strategy, a major food production effort, and the political courage to import on a sizable scale if required, in order to sustain the necessary growth and development in the Indian economy.

## Statistical Improvements

This section highlights some issues concerning data limitations for policy research that were encountered in this study. Attention has already been drawn to the large impact that poverty alleviation can have on growth of foodgrain demand. However, the effect of higher incomes in the upper- and middle-income groups on demand is not clear. While on the one hand their per capita demand for foodgrains for direct consumption may not increase rapidly, or may even decline somewhat, their demand for livestock products may increase, resulting in increased derived demand for foodgrains for feed. In the absence of reliable data on feedgrain use and quantities of livestock products consumed, this aspect could not be examined in detail here. The issue calls for collection and provision of such statistics on a national basis.

The allowances for seed, feed, and wastage now being applied by the Ministry of Agriculture in calculating the net availability of foodgrains for human consumption from the production estimates have not been changed since the early 1950s. The proportion of seed to yield per hectare is likely to have declined after the adoption of HYVs and the allowance needed to account for losses in storage and handling also could have declined. On the other hand, the requirements for feed would have increased with the increase in demand for livestock products and the current programs for development of livestock activities including dairying and poultry. It is important that the Government of India take measures to correct and update these estimates. Studies such as Bansil 1989 could be done on a national basis.

Consumption data from the NSSO consumption surveys are often available only after a considerable time lag. No quantitative data on nonfoodgrain consumption are available from these surveys. These data deficiencies need early attention. Beyond the national analysis in this study, a disaggregated analysis of consumption could be done at a regional level and should include items of food consumption besides cereals and pulses. This study also shows that foodgrain rainfall indices are very useful, and it is suggested that the Government of India should compute and publish such index numbers on a regular basis, adopting an appropriate standard methodology.

Some work on the determination of response coefficients for different inputs and crops is being done at the Indian Agricultural Research Statistics Institute. It would be useful if the institute would help undertake the regular revision of the input response yardsticks for foodgrains as a whole. Whereas this would be adequate for planning, for policy research—particularly in studying productivity—it would also be valuable to have measures of response for different states, regions, crops, and nutrients under different associated conditions.

# APPENDIX 1

# DECOMPOSITION OF YIELD INCREASE INTO PURE YIELD EFFECT AND CROPPING PATTERN EFFECT

$$Y = W_f Y_f + W_c Y_c ,$$

$$\Delta Y = \Delta Y_f W_f + \Delta W_f Y_f + \Delta W_f \Delta Y_f$$

$$+ \Delta Y_c W_c + \Delta W_c Y_c + \Delta W_c \Delta Y_c \text{ , and therefore}$$

$$\Delta Y = \Delta Y_f W_f + \Delta Y_c W_c \quad \text{(pure yield effect)}$$

$$+ \Delta W_f Y_f + \Delta W_c Y_c \text{ (cropping pattern effect)}$$

$$+ \Delta W_f \Delta Y_f + \Delta W_c \Delta Y_c \text{ (interaction),}$$

where

$$W_f = \frac{A_f}{A} ,$$

$$W_c = \frac{A_c}{A} ,$$

$$A = A_f + A_c ,$$

$Y$ = total foodgrain yield,

$Y_f$ = yield of fine grains (rice and wheat),

$Y_c$ = yield of coarse grains (coarse cereals and pulses),

$A$ = total foodgrain area,

$A_f$ = area under fine grains (rice and wheat), and

$A_c$ = area under coarse grains (coarse cereals and pulses).

# APPENDIX 2

# SOURCES AND METHODS FOR REGIONAL FOODGRAIN PRODUCTION DATA

A significant effort has been made in this study to put together consistent regional data on foodgrain area, production, and yield in India by crop, exhaustively covering the entire country from the early 1950s to the latest available year of firm estimates at the time of the analysis. An effort has been made to make each of these time series consistent and comparable over time so as to permit as accurate an analysis of these variables as possible. Foodgrain production data for India are reported under the 31 different states and union territories, which are listed below.

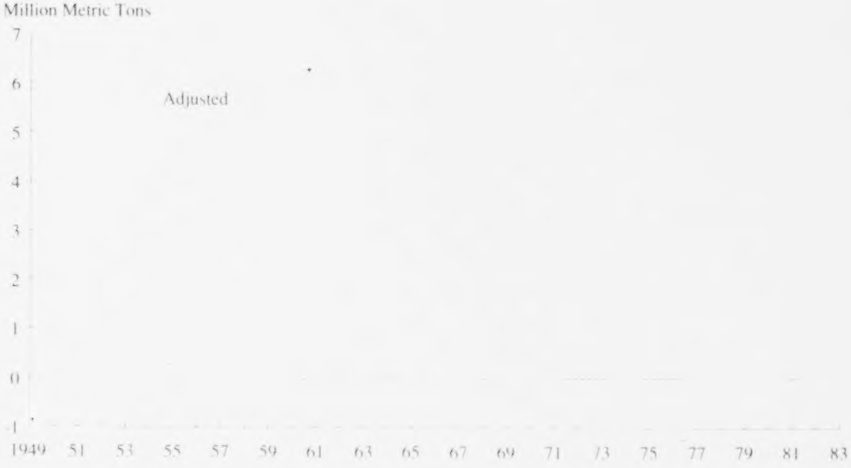
1. Andhra Pradesh
2. Assam
3. Bihar
4. Gujarat
5. Haryana
6. Himachal Pradesh
7. Jammu and Kashmir
8. Karnataka
9. Kerala
10. Madhya Pradesh
11. Maharashtra
12. Manipur
13. Meghalaya
14. Nagaland
15. Orissa
16. Punjab
17. Rajasthan
18. Sikkim
19. Tamil Nadu
20. Tripura
21. Uttar Pradesh
22. West Bengal
23. Andaman and Nicobar Islands
24. Arunachal Pradesh
25. Dadra and Nagar Haveli
26. Delhi
27. Goa, Daman, and Diu
28. Mizoram
29. Pondicherry
30. Chandigarh
31. Lakshadweep

For the early years, most of the data are reported in acres, long tons, and pounds and require conversion. The geographical coverage of the area reporting the crop estimates has expanded over time and the methods of yield estimation have also undergone a change in many of the states and union territories. Traditional methods of yield assessment based on eye estimates have been replaced by systematic crop-cutting surveys. All these changes cause noncomparability in the published time-series estimates, which then do not necessarily reflect real growth or changes. To add to the difficulty, these changes have taken place at different times in different states, and state boundaries too have sometimes changed because of reorganization of states.

In an effort to overcome these problems, which are very serious for time-series studies, the Directorate of Economics and Statistics, Ministry of Agriculture, has worked out and published a special set of adjusted estimates of foodgrain production for the period 1949/50-1964/65. In addition, index numbers of area, production, and yields of foodgrain crops, which reflect time series adjusted for the above-mentioned methodological and coverage changes, were also published. However, these are commonly available only for the aggregate all-India level. The Directorate at one point published similar adjusted index numbers for area, production, and yield for 15 major states, and these are available in a publication (India, Ministry of Agriculture 1968) that gives index numbers by crop for these states from 1952/53 to 1964/65. No major changes in methods of reporting or coverage of the crop estimates have taken place since 1964/65. The difference between "adjusted" and "unadjusted" estimates of all-India production of foodgrains for 1949/50 was as high as 6 million tons (Figure 19). This fluctuated from year to year and was gradually reduced to nil only by 1964/65, by which time most of the changes were completed.

For these 15 states, rather than using published unadjusted data from *Area and Production of Principal Crops in India* (India, Ministry of Agriculture), adjusted area and production data have been generated for 1952/53-1963/64 using the above-mentioned index numbers, with the 1964/65 index numbers and corresponding final estimates of area and production serving as the equating base. From the year 1964/65 onward, figures of area and production are directly adopted from *Area and Production of Principal Crops in India*. For the remaining states and union territories, figures for area and production were directly adopted from this publication for the entire period. The contribution of these remaining states and union territories to total foodgrain area and production is small. The area and production figures for each state and union territory were aggregated into regional figures for the Northern, Uttar Pradesh, Central, Western, Eastern, and Southern regions, based on the composition of each region given in Chapter 3.

**Figure 19—Difference between adjusted and unadjusted production estimates of foodgrains in India, 1949-83**



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years).

# APPENDIX 3

# REGIONAL GROWTH RATES AND THEIR t-STATISTICS

Table 33—Regional growth rates of foodgrain area, production, and yield

| | Rice | | | Wheat | | | Coarse Cereals | | | Total Cereals | | | Total Pulses | | | Total Foodgrains | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region/Period | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| | | | | | | | | | (percent/year) | | | | | | | | | |
| Northern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 4.64 | 5.99 | 1.29 | 3.30 | 5.25 | 1.89 | −0.17 | 2.45 | 2.62 | 1.84 | 4.39 | 2.52 | 1.37 | 1.23 | −0.14 | 1.64 | 3.58 | 1.91 |
| t-statistic | 11.90 | 10.90 | 4.30 | 11.70 | 13.20 | 3.40 | −0.51 | 3.50 | 5.38 | 10.27 | 11.20 | 7.05 | 1.13 | 0.75 | −0.12 | 4.42 | 8.32 | 4.40 |
| 1967/68-1975/76 | 4.54 | 10.24 | 5.45 | 2.75 | 4.49 | 1.69 | 0.21 | 0.85 | 0.65 | 1.98 | 4.38 | 2.36 | −1.98 | −5.77 | −3.85 | 1.26 | 3.30 | 2.02 |
| t-statistic | 24.26 | 9.85 | 6.00 | 3.60 | 3.08 | 2.00 | 0.32 | 0.86 | 0.63 | 8.04 | 4.08 | 2.60 | −1.05 | −1.53 | −1.65 | 2.65 | 3.25 | 2.57 |
| 1975/76-1983/84 | 8.38 | 11.36 | 2.75 | 3.20 | 6.36 | 3.07 | −3.69 | −2.03 | 1.73 | 2.16 | 6.19 | 3.95 | −7.55 | −14.42 | −7.43 | 0.89 | 5.13 | 4.21 |
| t-statistic | 7.90 | 7.75 | 2.90 | 14.70 | 15.60 | 10.90 | −5.62 | −1.40 | 1.95 | 13.80 | 15.35 | 9.95 | −3.20 | −5.02 | −2.95 | 2.90 | 10.55 | 10.50 |
| Uttar Pradesh | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.83 | 4.29 | 2.42 | 0.84 | 1.54 | 0.70 | −0.93 | −0.61 | 0.33 | 0.38 | 1.46 | 1.08 | 0.53 | −1.20 | −1.72 | 0.42 | 0.79 | 0.37 |
| t-statistic | 18.30 | 6.06 | 3.50 | 2.75 | 1.55 | 0.73 | −5.40 | −1.00 | 0.58 | 2.78 | 2.65 | 2.10 | 3.38 | −1.37 | −1.80 | 3.50 | 1.38 | 0.67 |
| 1967/68-1975/76 | 0.22 | 2.90 | 2.66 | 2.86 | 3.14 | 0.27 | −1.87 | −1.74 | 0.13 | 0.44 | 1.69 | 1.25 | −3.51 | −5.36 | −1.92 | −0.32 | 0.52 | 0.84 |
| t-statistic | 0.70 | 2.60 | 2.70 | 6.10 | 2.05 | 0.21 | −6.30 | −1.15 | 0.09 | 2.80 | 1.60 | 1.35 | −11.60 | −2.90 | −0.99 | −2.50 | 0.49 | 0.83 |
| 1975/76-1983/84 | 1.81 | 4.83 | 2.97 | 3.83 | 8.34 | 4.33 | −3.23 | −1.97 | 1.30 | 1.36 | 5.51 | 4.09 | −0.95 | −0.70 | 0.24 | 1.01 | 4.81 | 3.77 |
| t-statistic | 4.40 | 1.30 | 0.83 | 10.50 | 8.20 | 4.60 | −8.65 | −0.96 | 0.70 | 5.75 | 3.30 | 2.50 | −2.80 | −0.31 | 0.10 | 5.60 | 2.80 | 2.25 |
| Central | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.30 | 2.17 | 0.86 | 3.49 | 2.74 | −0.73 | 1.30 | 2.27 | 0.95 | 1.72 | 2.34 | 0.60 | 2.08 | 2.62 | 0.53 | 1.82 | 2.38 | 0.56 |
| t-statistic | 17.97 | 1.80 | 0.73 | 4.30 | 2.50 | −1.23 | 4.74 | 2.50 | 1.40 | 11.50 | 4.20 | 1.30 | 4.16 | 2.30 | 0.68 | 8.70 | 3.80 | 1.17 |
| 1967/68-1975/76 | 1.12 | 0.57 | −0.54 | 2.08 | 5.02 | 2.88 | −1.34 | −0.72 | 0.63 | −0.08 | 1.26 | 1.34 | 2.61 | 4.09 | 1.43 | 0.66 | 1.84 | 1.17 |
| t-statistic | 4.80 | 0.27 | −0.26 | 1.86 | 3.04 | 3.10 | −2.00 | −0.31 | 0.28 | −0.16 | 0.73 | 0.85 | 3.50 | 2.15 | 1.08 | 1.55 | 1.06 | 0.80 |
| 1975/76-1983/84 | 0.73 | 1.85 | 1.11 | 1.24 | 5.62 | 4.34 | 1.94 | 3.16 | 1.20 | 1.49 | 3.74 | 2.21 | −0.77 | −0.48 | 0.30 | 0.83 | 2.87 | 2.02 |
| t-statistic | 4.20 | 0.47 | 0.30 | 1.50 | 3.50 | 4.30 | 4.17 | 1.06 | 0.40 | 6.30 | 1.60 | 0.99 | −1.05 | −0.18 | 0.14 | 3.80 | 1.20 | 0.94 |
| Western | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.87 | 4.29 | 2.38 | 1.19 | 3.48 | 2.28 | 0.01 | 2.41 | 2.41 | 0.34 | 2.98 | 2.63 | −0.34 | −0.27 | 0.07 | 0.22 | 2.59 | 2.37 |
| t-statistic | 12.30 | 8.40 | 4.90 | 1.70 | 3.80 | 2.70 | 0.07 | 3.90 | 3.90 | 5.90 | 5.40 | 5.40 | −0.84 | −0.35 | 0.11 | 1.60 | 4.90 | 4.80 |
| 1967/68-1975/76 | −0.43 | 1.38 | 1.82 | 1.75 | 8.24 | 6.39 | −1.20 | 1.57 | 2.82 | −0.84 | 2.22 | 3.09 | 1.86 | 3.56 | 1.68 | −0.39 | 2.36 | 2.76 |
| t-statistic | −0.82 | 0.58 | 0.95 | 0.97 | 2.40 | 3.80 | −1.20 | 0.60 | 1.70 | −0.87 | 0.87 | 1.90 | 1.37 | 1.07 | 0.86 | −0.38 | 0.90 | 1.72 |
| 1975/76-1983/84 | 0.78 | 1.42 | 0.63 | −1.02 | 1.13 | 2.17 | 0.04 | 1.19 | 1.15 | 0.04 | 1.23 | 1.19 | 1.59 | 2.87 | 1.26 | 0.32 | 1.38 | 1.05 |
| t-statistic | 2.70 | 1.09 | 0.60 | −1.95 | 1.02 | 2.50 | 0.12 | 1.07 | 1.24 | 0.12 | 1.25 | 1.60 | 3.05 | 1.70 | 0.97 | 0.96 | 1.38 | 1.47 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eastern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 0.69 | 2.19 | 1.49 | 0.71 | 2.23 | 1.51 | 0.72 | 2.21 | 1.48 | 0.70 | 2.20 | 1.49 | 0.57 | 1.10 | 0.52 | 0.68 | 2.07 | 1.38 |
| t-statistic | 5.40 | 2.90 | 2.26 | 0.83 | 1.20 | 0.73 | 1.47 | 2.50 | 3.10 | 4.82 | 3.12 | 2.47 | 0.96 | 1.05 | 0.66 | 3.30 | 2.90 | 2.40 |
| 1967/68-1975/76 | 0.72 | 0.64 | −0.08 | 9.61 | 15.11 | 5.01 | −0.11 | −2.26 | −2.16 | 1.33 | 1.73 | 0.41 | 0.60 | −2.66 | −3.24 | 1.23 | 1.39 | 0.15 |
| t-statistic | 2.90 | 0.84 | −0.11 | 3.60 | 3.90 | 2.25 | −0.15 | −0.64 | −0.73 | 7.55 | 2.32 | 0.63 | 1.20 | −2.20 | −4.20 | 7.04 | 1.98 | 0.25 |
| 1975/76-1983/84 | −0.73 | −0.58 | 0.15 | −1.87 | −0.89 | 1.02 | −1.32 | 0.99 | 2.35 | −0.91 | −0.48 | 0.43 | 0.42 | 3.19 | 2.75 | −0.74 | −0.22 | 0.52 |
| t-statistic | −1.83 | −0.30 | 0.09 | −2.40 | −0.50 | 0.85 | −1.90 | 0.75 | 2.30 | −2.40 | −0.27 | 0.30 | 0.60 | 2.60 | 2.45 | −2.03 | −0.13 | 0.40 |
| Southern | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 2.62 | 4.64 | 1.96 | 1.61 | 1.15 | −0.46 | −0.60 | 2.12 | 2.74 | 0.87 | 3.82 | 2.92 | 0.28 | −0.18 | −0.46 | 0.79 | 3.67 | 2.84 |
| t-statistic | 11.60 | 12.70 | 9.60 | 1.06 | 0.60 | −0.57 | −2.70 | 5.16 | 7.80 | 5.40 | 11.60 | 11.30 | 1.20 | −0.38 | −1.40 | 5.10 | 11.20 | 11.30 |
| 1967/68-1975/76 | 0.46 | 2.88 | 2.40 | 9.24 | 28.94 | 18.02 | −0.58 | 1.62 | 2.21 | −0.03 | 2.56 | 2.58 | 1.79 | 6.07 | 4.21 | 0.20 | 2.66 | 2.46 |
| t-statistic | 0.96 | 3.40 | 3.80 | 9.30 | 8.50 | 6.20 | −1.60 | 1.98 | 3.30 | −0.06 | 3.70 | 5.45 | 2.85 | 3.45 | 3.20 | 0.55 | 3.80 | 5.35 |
| 1975/76-1983/84 | −0.68 | 1.93 | 2.63 | −4.90 | −4.64 | 0.27 | −2.98 | −1.28 | 1.76 | −1.72 | 1.12 | 2.89 | 1.55 | 5.24 | 3.63 | −1.28 | 1.27 | 2.58 |
| t-statistic | −0.90 | 1.50 | 3.60 | −3.20 | −1.15 | 0.09 | −5.50 | −1.15 | 2.25 | −2.80 | 0.95 | 4.20 | 4.09 | 3.90 | 3.10 | −2.25 | 1.10 | 3.70 |
| All India | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65 | 1.57 | 3.34 | 1.74 | 2.29 | 3.32 | 1.02 | 0.21 | 1.38 | 1.16 | 0.99 | 2.63 | 1.62 | 1.36 | 0.62 | −0.73 | 1.07 | 2.33 | 1.25 |
| t-statistic | 20.80 | 7.02 | 3.94 | 4.90 | 5.20 | 1.65 | 1.30 | 3.30 | 3.80 | 9.60 | 7.20 | 5.60 | 4.50 | 0.90 | −1.30 | 8.40 | 6.10 | 4.00 |
| 1967/68-1975/76 | 0.67 | 1.89 | 1.21 | 3.20 | 5.47 | 2.18 | −1.07 | 0.27 | 1.35 | 0.31 | 2.22 | 1.90 | 0.77 | −0.51 | −1.27 | 0.40 | 1.91 | 1.50 |
| t-statistic | 3.50 | 2.00 | 1.40 | 5.55 | 3.89 | 2.65 | −3.40 | 0.19 | 1.29 | 1.40 | 3.30 | 3.80 | 1.50 | −0.20 | −1.17 | 1.50 | 2.80 | 3.05 |
| 1975/76-1983/84 | 0.22 | 1.97 | 1.75 | 1.94 | 5.72 | 3.72 | −0.46 | 0.68 | 1.14 | 0.31 | 2.77 | 2.45 | −0.32 | −0.22 | 0.11 | 0.19 | 2.48 | 2.28 |
| t-statistic | 0.48 | 1.33 | 1.50 | 4.50 | 7.90 | 6.70 | −1.15 | 0.79 | 1.58 | 1.50 | 2.65 | 2.80 | 0.15 | 0.51 | 0.57 | 1.25 | 2.40 | 2.60 |

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

# APPENDIX 4

# SOURCES AND METHODS FOR INPUT DATA AND RESPONSE COEFFICIENTS

## Input Data

### Fertilizers

The basic source of fertilizer data is *Fertilizer Statistics*, published annually by the Fertilizer Association of India in New Delhi. The data on fertilizer consumption relate to nitrogenous, phosphatic, and potassic fertilizers and are based on dispatches to the retail trade. Therefore they do not include stock changes at the retail and farmer levels. The data are indicative of the total fertilizer use on all crops but do not give the amount or percentage that is applied to foodgrains each year. An IFPRI research report (Desai 1982) provides a rigorous study of the pattern of fertilizer use in India as well as several benchmark estimates on this issue. The report estimates, on the basis of NSS survey data, that 45 percent of the fertilizer used in 1955/56 went to foodgrains and that by 1970/71 this share had risen to 56 percent. Further, on the basis of a survey by the National Council of Applied Economic Research, the report estimates that by 1976/77 this figure had risen to 70 percent. It is assumed in this study that the share of fertilizers going to foodgrains rose more slowly to 75 percent by 1983/84.

Between these benchmarks, linear (steady) rate increases have been assumed in the percentage share between 1976/77 and 1983/84, and between 1970/71 and 1976/77. The annual rate of increase between 1970/71 and 1976/77 was adopted for the period between 1967/68 and 1970/71 also, under the assumption that a certain acceleration for foodgrains began from the first year of the green revolution, namely 1967/68. Again, a linear rate of increase is assumed between the benchmark of 1955/56 and the year 1967/68, and the annual rate of increase between these two years has been extended back to 1949/50. Estimating annual utilization of fertilizers using linear rates of increase and relating the production potential created to fluctuating foodgrain production is open to objection. It can at best give approximate relationships, and caution is required in reaching conclusions from these data. Table 34 shows the relevant data along with the implied average per hectare rate of application of fertilizers to foodgrains and nonfoodgrains. It may be noted that the average per hectare rate for nonfoodgrains is higher than that for foodgrains during most of the period until the early 1980s, when it is surpassed by the rate for foodgrains. This is consistent with the more rapid increase in the foodgrain yield index compared with the nonfoodgrain yield index around this period. For 1967/68 the fertilizer consumption figure given in Table 34 is 1,539,900 tons, whereas that given in Table 7 is 1,166,000 tons. This difference between the aggregate and the disaggregate data exists in the Indian fertilizer statistics and cannot be currently resolved without further information.

### High-Yielding Varieties

High-yielding varieties (HYVs) started entering Indian agriculture in a significant way in 1967/68. The data for this are obtained from *Area and Production of Principal*

## Table 34—Fertilizer use in India, 1949/50-1983/84

| Year | Total Fertilizer Consumption | Share of Fertilizer for Foodgrains | Total Amount of Fertilizer for Foodgrains | Fertilizer for Foodgrains per Hectare | Fertilizer for Nonfoodgrains per Hectare |
|---|---|---|---|---|---|
| | (1,000 metric tons) | (percent) | (1,000 metric tons) | (kilograms) | (kilograms) |
| 1949/50 | 22.8 | 43.00 | 9.80 | 0.10 | 0.39 |
| 1950/51 | 36.4 | 43.33 | 15.77 | 0.16 | 0.58 |
| 1951/52 | 65.6 | 43.67 | 28.65 | 0.30 | 1.01 |
| 1952/53 | 65.7 | 44.00 | 28.91 | 0.28 | 1.02 |
| 1953/54 | 105.1 | 44.33 | 46.59 | 0.43 | 1.73 |
| 1954/55 | 120.9 | 44.67 | 54.00 | 0.50 | 1.85 |
| 1955/56 | 130.8 | 45.00 | 58.86 | 0.53 | 1.96 |
| 1956/57 | 153.8 | 45.33 | 69.72 | 0.63 | 2.19 |
| 1957/58 | 183.7 | 45.67 | 83.89 | 0.77 | 2.74 |
| 1958/59 | 223.8 | 46.00 | 102.95 | 0.90 | 3.27 |
| 1959/60 | 304.6 | 46.33 | 141.13 | 1.23 | 4.34 |
| 1960/61 | 293.8 | 46.67 | 137.11 | 1.19 | 4.20 |
| 1961/62 | 338.3 | 47.00 | 159.00 | 1.36 | 4.55 |
| 1962/63 | 452.2 | 47.33 | 214.04 | 1.81 | 6.14 |
| 1963/64 | 543.9 | 47.67 | 259.26 | 2.21 | 7.19 |
| 1964/65 | 773.2 | 48.00 | 371.14 | 3.14 | 9.79 |
| 1965/66 | 784.6 | 48.33 | 379.22 | 3.29 | 10.09 |
| 1966/67 | 1,100.6 | 48.67 | 535.[illegible]3 | 4.65 | 13.44 |
| 1967/68 | 1,539.9 | 49.00 | 754.55 | 6.21 | 18.56 |
| 1968/69 | 1,760.7 | 51.33 | 903.83 | 7.50 | 21.91 |
| 1969/70 | 1,982.4 | 53.67 | 1,063.89 | 8.61 | 23.74 |
| 1970/71 | 2,256.0 | 56.00 | 1,263.36 | 10.16 | 23.93 |
| 1971/72 | 2,656.9 | 58.33 | 1,549.86 | 12.64 | 26.01 |
| 1972/73 | 2,767.9 | 60.67 | 1,679.19 | 14.08 | 25.40 |
| 1973/74 | 2,838.6 | 63.00 | 1,788.32 | 14.13 | 24.24 |
| 1974/75 | 2,573.3 | 65.33 | 1,681.22 | 13.89 | 20.69 |
| 1975/76 | 2,893.8 | 67.67 | 1,958.14 | 15.28 | 21.70 |
| 1976/77 | 3,411.0 | 70.00 | 2,387.70 | 19.20 | 23.80 |
| 1977/78 | 4,285.8 | 70.71 | 3,030.67 | 23.77 | 28.05 |
| 1978/79 | 5,116.9 | 71.43 | 3,654.93 | 28.33 | 31.96 |
| 1979/80 | 5,255.4 | 72.14 | 3,791.40 | 30.28 | 32.94 |
| 1980/81 | 5,515.6 | 72.86 | 4,018.51 | 31.72 | 32.24 |
| 1981/82 | 6,064.0 | 73.57 | 4,461.37 | 34.55 | 33.45 |
| 1982/83 | 6,388.0 | 74.29 | 4,745.37 | 37.94 | 34.55 |
| 1983/84 | 7,710.0 | 75.00 | 5,782.50 | 44.09 | 40.09 |

Sources: Authors' calculations based on data from Fertilizer Association of India, *Fertilizer Statistics* (New Delhi: FAI, various years).

*Crops in India* (India, Ministry of Agriculture) for the number of hectares of gross cropped area and cover HYVs of rice, wheat, maize, *jowar*, and *bajra*. These data are obtained from the state governments, who base their estimates on data furnished by the primary reporting agencies after periodic crop inspection. In some states the data are based on the reports of agricultural extension and other staff of the agricultural department.

### Irrigation

Data for irrigated area for foodgrains are obtained from *Indian Agriculture in Brief* (India, Ministry of Agriculture) for the number of hectares of gross irrigated area. These data are also based on the reports furnished by the primary reporting agencies of the Revenue/Land Records departments after periodic crop inspection. In some states, the data are furnished by the staff of the irrigation departments. There is also another source of data on irrigation, namely, the progress reports on major, medium, and minor irrigation schemes submitted by the respective departments. There are wide differences between the data from these two sources. For the present study the former source has been adopted.

## Basis of Response Coefficients

Sarma and Roy (1979) adopted the following response coefficients (yardsticks) for assessing input response in foodgrain production: 0.50 tons per hectare for irrigation, 10.00 tons per ton of nutrient (NPK) for fertilizers, 0.45 tons per hectare for additional area under foodgrains, and 0.33 tons per hectare for the shift in area to rice and wheat from coarse cereals and pulses. It is assumed that these response coefficients are additive though the inputs are applied in combination. Fertilizer response is assumed to include the HYV response.

The response coefficients for irrigation and fertilizers were the same as those that have been used in national planning in India for determining food production targets fixed, in part, on the basis of production potential. To arrive at the other coefficients, the estimated contribution of irrigation and fertilizers was subtracted from the average foodgrain output in 1959/60-1961/62, that is, 80.62 million tons. The balance (67.81 million tons) was subdivided into two parts representing the outputs of (1) rice and wheat and (2) coarse cereals and pulses. The latter was estimated using the average yield of coarse cereals and pulses (0.45 tons per hectare). The average yield of rice and wheat (excluding the contribution of irrigation and fertilizers) was then derived as 0.78 tons per hectare. Thus the yardstick of additional production for shift of area from other foodgrains to rice and wheat was estimated as 0.78 – 0.45 = 0.33 tons per hectare. No separate response coefficient for labor was adopted.

Considerable work was done on the yardsticks or response coefficients by the Indian Agricultural Statistics Research Institute (IASRI) in the 1960s, based on the data on field trials. The National Commission on Agriculture (India, Ministry of Agriculture 1976) also reviewed the available data and arrived at the response coefficients of fertilizers at 8 for traditional varieties and 10 for an average of traditional and high-yielding varieties. But these have not been reviewed since then. Although IASRI is continuing its work on yardsticks, no updated composite yardsticks in a form suitable for application in the computation of production potential have been evolved.[17]

## Calculation of the Rainfall Index

Rainfall data are reported by the India Meteorological Department on a compiled basis for 32 different rainfall zones (Table 35). *Agricultural Situation in India* (India, Ministry of Agriculture) reports rainfall received in each of the 32 zones in the four seasons of each year: monsoon, June-September; postmonsoon, October-December; winter, January-February; and premonsoon, March-May. Actual rainfall received and normal rainfall in each season is reported for each zone.

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[17] IASRI recently brought out a monograph on yardsticks for irrigation, but these are given in output per centimeter of water for selected individual crops at different centers.

## Table 35—Rainfall reporting zones in India

| State/Zone | Share in Gross Sown Area, 1973/74 |
|---|---|
| | (percent) |
| Andhra Pradesh | |
| Coastal | 2.7 |
| Telangana | 3.3 |
| Rayalaseema | 1.8 |
| Assam and Meghalaya | 1.9 |
| Bihar | |
| Plateau | 1.6 |
| Plains | 4.7 |
| Gujarat | |
| Gujarat region | 3.5 |
| Saurashtra, Kutch, and Diu | 2.7 |
| Haryana | 3.0 |
| Himachal Pradesh | 0.5 |
| Jammu and Kashmir | 0.5 |
| Karnataka | |
| Coastal | 0.2 |
| Interior north | 3.6 |
| Interior south | 2.6 |
| Kerala | 1.8 |
| Madhya Pradesh | |
| East | 5.3 |
| West | 7.3 |
| Maharashtra | |
| Konkan and Goa | 0.5 |
| Madhya Maharashtra | 4.7 |
| Marathwada | 3.1 |
| Vidarbha | 3.2 |
| Nagaland, Manipur, Mizoram, and Tripura | 0.5 |
| Orissa | 4.3 |
| Punjab | 3.6 |
| Rajasthan | |
| East | 4.9 |
| West | 5.7 |
| Tamil Nadu | 4.5 |
| Uttar Pradesh | |
| East | 8.0 |
| West (Plains) | 5.0 |
| West (Hills) | 0.7 |
| West Bengal | |
| Sub-Himalayan and Sikkim | 1.2 |
| Gangetic | 3.1 |
| All India | 100.0 |

Source: Based on data from Center for Monitoring Indian Economy, *Basic Statistics Relating to the Indian Economy,* vols. 1 and 2 (Bombay: CMIE, 1984).

In this study, for the *kharif* crops, the monsoon and postmonsoon rainfall are considered the most relevant. Therefore, for each zone the rainfall received in these two seasons is added and expressed as an index or percentage in relation to the normal rainfall. This is called the *kharif* rainfall index for the zone. For the *rabi* crops, the postmonsoon and winter rainfall are considered the most relevant and these are similarly computed into a *rabi* rainfall index for the zone.

State (a state may have several zones) *kharif* and *rabi* rainfall indices are computed from the zonal indices by using the gross sown area in the reference year of 1973/74 in each zone as the weights (Table 35). A state rainfall index is then computed for each crop year by using the state *kharif* and *rabi* average foodgrain production in the reference period 1972/73-1974/75 as weights. This is an improvement over the Cummings and Ray (1969) methodology (also adopted by Sanderson and Roy [1979]), which makes a prior classification of states into groups and applies only the *kharif* index to one group of states.

The state rainfall indices are then converted into an all-India rainfall index for each year by using the average foodgrain production in each state in the reference period 1972/73-1974/75 as weights. In this manner, the gross sown area and the foodgrain production are allowed to do all the weighting for aggregations across zones and states, and no other prior classifications are applied.

Given the limitations of time and data, indices were computed in this manner for the years 1973/74-1983/84. For the years 1951/52-1968/69 the Cummings and Ray indices (for cereals) were adopted, and for the years 1969/70-1972/73 the Sanderson and Roy extension of the indices was adopted. The overlapping period of the two indices (1973/74-1977/78) showed that both were highly correlated and close; therefore, there was little problem in merging them.

# APPENDIX 5

# RESULTS OF FACTOR ANALYSIS ON FOODGRAIN PRODUCTION DETERMINANTS

A. Principal components on six variables; three factors retained.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Eigenvalues: | | | | | | |
| | 4.7038 | 0.97192 | 0.27927 | 0.03018 | 0.008727 | 0.006070 |
| Sum of eigenvalues = 6.0000 | | | | | | |
| Cumulative percentage of eigenvalues: | | | | | | |
| | 0.78397<br>78% | 0.94596<br>16% | 0.99250<br>5% | 0.99753 | 0.99899 | 1.0000 |
| Eigenvectors: | | | | | | |
| Vector 1 | | | | | | |
| | 0.42409 | 0.45532 | 0.43816 | 0.44569 | 0.45518 | 0.12261 |
| Vector 2 | | | | | | |
| | 0.10725 | −0.02947 | −0.10401 | −0.09805 | −0.13665 | 0.97392 |
| Vector 3 | | | | | | |
| | 0.70253 | 0.24764 | −0.50183 | −0.40833 | 0.02405 | −0.16120 |
| Factor matrix (three factors): | | | | | | |
| Variable afg | | | | | | |
| | 0.91977 | 0.10573 | 0.37126 | | | |
| Variable arw | | | | | | |
| | 0.98750 | −0.02905 | 0.13087 | | | |

Variable frfg

0.95029 −0.10254 −0.26520

Variable hvfg

0.96662 −0.09666 −0.21579

Variable irfg

0.98721 −0.13472 0.01270

Variable rain

0.26591 0.96015 −0.08518

| Iteration Cycle | Variances |
|---|---|
| 0 | 0 .223537 |
| 1 | 0 .282626 |
| 2 | 0 .285571 |
| 3 | 0 .285575 |
| 4 | 0 .285575 |
| 5 | 0 .285575 |
| 6 | 0 .285575 |
| 7 | 0 .285575 |

B. Results of factor analysis on foodgrain production determinants.

Rotated factor matrix (three factors):

| Factor | 1 | 2 | 3 |
|---|---|---|---|
| Factor identification | Technology/ Inputs | Rainfall | Area |
| Variable | | | |
| afg (area) | 0.50537 | 0.19469 | *0.83767* |
| arw (rice/wheat) | 0.72269 | 0.10649 | 0.67787 |
| frfg (fertilizers) | *0.93102* | 0.08348 | 0.33185 |
| hvfg (HYV) | *0.91506* | 0.08495 | 0.38171 |
| irfg (irrigation) | *0.81075* | 0.01938 | 0.57895 |
| rain (rainfall) | 0.06285 | *0.99221* | 0.10688 |

Check on communalities:

| Variable | Original | Final | Difference |
|---|---|---|---|
| 1 | 0.99499 | 0.99499 | 0.47367E-06 |
| 2 | 0.99313 | 0.99313 | 0.49816E-06 |
| 3 | 0.98389 | 0.98389 | 0.50197E-06 |
| 4 | 0.99027 | 0.99027 | 0.50461E-06 |
| 5 | 0.99289 | 0.99288 | 0.50796E-06 |
| 6 | 0.99986 | 0.99986 | 0.81344E-08 |

# APPENDIX 6

# VARIABLE NAMES AND DEFINITIONS IN PRODUCTION FUNCTION ANALYSIS

YIELD = Yield of foodgrains in kilograms per hectare. This is an average yield obtained by dividing the foodgrain production by the gross cropped area under foodgrains. Both production and area figures are adjusted for changes in coverage and methodology over the years.

FERT = Fertilizer use in kilograms per hectare. This is obtained by dividing the quantity of fertilizers applied to foodgrains (see Appendix 4) by the gross cropped area under foodgrains. The fertilizer data are for an April-March year, but given the cropping practices in India, this requires no adjustment for the July-June crop-year basis of the rest of the data.

HYV = Percent coverage of high-yielding varieties. This is obtained by dividing the gross cropped foodgrain area under HYVs by the total gross cropped area under foodgrains. In an input-output context, assuming a constant HYV seed rate, this represents the per unit average HYV seed use.

IRRIG = Percent coverage of irrigation. This is obtained by dividing the gross irrigated foodgrain area by the gross cropped area under foodgrains. In an input-output context, assuming a constant rate of irrigation, this represents the average irrigation application per unit of area.

RAIN = Foodgrain rainfall index. This is the all-India foodgrain rainfall index and represents an index of the weighted average rainfall actually received for foodgrain crops per unit of area (see Appendix 4).

# APPENDIX 7

# METHODS ADOPTED IN USING NATIONAL SAMPLE SURVEY CONSUMPTION DATA

The National Sample Survey (NSS) consumer expenditure data on foodgrains (India, Department of Statistics) are available annually up to 1973/74; subsequently, they are available for 1977/78 and 1983. The principal focus of this study is on the 1977/78 and 1983 data. As a convenient past reference point, main use has been made of the year 1970/71, in part because a more detailed breakdown is available from the 1970/71 survey on food items through a special report made on this by the National Sample Survey Organization (NSSO) to the National Commission on Agriculture (India, Department of Statistics 1975).

For cereals and pulses, quantity as well as value data are available by income (total expenditure) group in the 1970/71 survey. From the mean values and quantities, implicit consumer prices for cereals and pulses are computed for the year 1970/71 for the rural and urban areas. In lieu of any alternative information, wholesale price indices for cereals and pulses are used to shift these mean consumer prices to 1977/78 and 1983. In this way, the wholesale-consumer and the rural-urban price differentials are maintained. The 1977/78 and 1983 survey data provide the quantity data for cereals, but the pulse data are only in value terms; therefore, mean values are converted to quantity by applying the estimated 1977/78 and 1983 prices for pulses. The rural and urban mean per capita consumption levels for cereals, pulses, and foodgrains thus obtained for 1977/78 and 1983 are converted to national estimates by applying rural-urban population ratios computed from census estimates.

The nonavailability of quantity data for pulses in 1977/78 and 1983 survey publications poses more difficult problems for analysis of the data by income group and quartile. Quantity as well as value data are available for the 1970/71 survey, and implicit prices calculated from this show that the prices vary considerably and broadly over income groups, being low for low-income groups and high for high-income groups. Part of the price differentials may be due to the quality composition of the pulses consumed by different income groups. Given such a distribution of prices, it would be incorrect to apply a uniform price across income groups for estimation of quantities. Another problem is that the nominal income groups vary from survey to survey, and even if they are the same, the real value they reflect is not equal, because of the substantial inflation taking place over time.

From the 1970/71 survey data, implicit prices can be calculated for cereals and pulses for each of the income groups and these are divided by the mean price of cereals and pulses for this year, giving the distribution of the prices around the mean. It is found that a log-log function between this price ratio and the mean income (total expenditure) levels of each group provides a good fit for the price distribution. It is assumed, therefore, that a relationship of this form exists between the real income (real total expenditure) levels and the implicit prices (expressed as a ratio of the price to the mean price), and this could be used for other years. The mean income levels of the different income (total expenditure) groups for the 1977/78 survey are deflated to the (real) 1970/71 price level by applying the agricultural-labor consumer price index for the rural areas and the working-class consumer price index for the urban areas. No quantity data are available for pulses from the 1977/78 survey. Therefore the real income levels for 1977/78 are applied to the 1970/71 estimated log-log price distribution function for pulses to give a distribution of pulse prices around the mean for 1977/78. The mean pulse price for 1977/78 is computed by moving the 1970/71 mean pulse price to 1977/78 by using the wholesale price index of pulses. Applying this mean price to the computed distribution, a pulse price is generated for each income group. Applying these prices to the already available values, quantities of pulse consumption are generated for each income group.

Quantity data are also unavailable from the 1983 survey for pulses, so the above method is repeated to estimate the quantity data by income group for 1983. The 1970/71 estimated price distribution function is used for pulses, applying the appropriate deflated real income data. An observation of the plots of actual and fitted data for 1970/71 showed that this method works well but may have a very slight tendency to overestimate the low-income group consumption and underestimate the high-income group consumption.

Quartiles are based on the sample frequency distribution of numbers of households and use the per capita income (total expenditure) group means provided by the survey data as well as the available or otherwise computed per capita consumption quantities. The consumption at specific income levels is read off from a discrete function plot between income and consumption, assuming straight-line changes between the points of observation reported with respect to each income group.

It may be added that the estimates of per capita availability derived from the Ministry of Agriculture's figures and those of per capita consumption obtained from the NSSO are not strictly comparable for a number of reasons. First, the ministry figures are based as supply-utilization balances and represent the disappearance concept. The NSS data represent direct estimates of per capita household consumption obtained by the interview method. Second, to the extent that the ministry takes into account changes in government stocks only, and not those with private trade and farmers and consumers, the per capita availability figures are approximate. They do not represent annual fluctuations correctly. To avoid this difficulty, three-year moving averages are sometimes considered. Third, the NSS per capita consumption figures relate to household consumption only and do not include nonhousehold consumption such as hotels; thus they may underestimate the consumption.

# APPENDIX 8

# METHODOLOGY FOR PROJECTIONS

## Assumptions in Projections of Foodgrain Production and Consumption to Year 2000

### Production Projection

The projections are worked out separately for rice, wheat, coarse cereals, and pulses disaggregated over the six regions of the country—Northern, Uttar Pradesh, Central, Western, Eastern, and Southern—and are based on adjusted state data from national sources. This is the base scenario.

Area and yield are projected separately using their trend growth rates (modified if necessary as explained below) and are finally multiplied to give the production projections. Growth rates are applied to 1983/84 trend values.

Post-green-revolution (1967/68-1983/84) semilogarithmic trend growth rates are used for both area and yield.

Area projections require some adjustment to make them realistic. Within each region, area under each crop/crop-group as well as that of total foodgrains is projected using their growth rates. Then, considering the projected total foodgrain area as a ceiling, the individual crop/crop-group areas are adjusted proportionately to give their projected areas.

The Northern region foodgrain area growth rate is constrained to 0.5 percent. Yield growth rates are constrained to be nonnegative, and a ceiling of 3.0 percent is also applied on the growth rate. This procedure affects yield growth rates in rice in the Northern region, wheat in the Uttar Pradesh, Central, Western, and Southern regions, and coarse grains in the Western region.

For the Eastern region, the yield growth rate is assumed to accelerate to 2.5 percent for rice and 2.0 percent for foodgrains.

The rice yield and production figures are in terms of milled rice.

Alternative projections for production were generated by two different methods. First, the projection for production is done by aggregating all foodgrains in each region on the basis of area and yield (scenario 2). The second method projects production based on area and yield of foodgrains at the all-India level using the all-India area and yield growth rates (scenario 3).

### Consumption Projection

Given the continuing differences between the Ministry of Agriculture's per capita availability data and the National Sample Survey Organization's per capita consumption data, and the need for maintaining comparability with the production data, the projections use the ministry's availability data for the absolute quantities. But the ratios and elasticities computed from the NSS data for 1977/78 are applied for some of the disaggregations and responses.

The starting points for the projections are the 1982-84 average per capita availability levels for wheat, rice, coarse cereals, and pulses. These national-level figures are decomposed into rural and urban per capita availability/consumption levels by applying proportions calculated from the 1977/78 NSS data and proportions of rural and urban populations.

The projected income growth rate of 5.0 percent for the country for the Perspective Plan given in the Seventh Five-Year Plan (India, Planning Commission 1985, vol. 1, chap. 2) is used and is decomposed into 2.5 percent for rural (agriculture) and 6.0 percent for urban (nonagriculture) on the basis of the midpoint sectoral income shares of agriculture and nonagriculture sectors projected to the year 2000 in the Seventh Five-Year Plan.

The first future scenario assumes the continuation of past per capita income growth rates. The second future scenario assumes the income growth rates indicated in the previous paragraph. The third scenario assumes an increase in income growth rates, with the rural income growth rate rising to 3.0 percent and the urban income growth rate to 7.0 percent, giving an overall income growth rate of 5.7 percent. The fourth scenario assumes a further acceleration of income growth rates to 3.5 percent for rural and 8.0 percent for urban, implying a growth rate of 7.0 percent for the economy.

Alternative scenarios were also generated in relation to change in the income distribution as follows (in percentages):

| | Base (1983) | Projected (2000) |
|---|---|---|
| Rural | 12/18/25/44 | 15/20/25/40 |
| Urban | 11/17/24/48 | 15/20/25/40 |

## Projections of Requirements for Seed, Feed, Industrial Use, and Wastage

In deriving the estimates of net availability for human consumption from the estimates of gross production of foodgrains, the Indian Ministry of Agriculture deducts for seed, feed, and wastage an overall allowance of 12.5 percent from the gross production. This consists of approximately 5.0 percent for seed, 5.0 percent for feed, and 2.5 percent for wastage. By crop, the overall allowances are about 7.6 percent for rice, 8.2 percent for wheat, and 12.5 percent each for the totals of cereals and of pulses. These allowances have not been revised since the early 1950s. With the introduction of HYVs of cereals, the seed requirements as a proportion of production may have declined. On the other hand, the use of foodgrains in livestock feed may have increased. No separate allowance is made for industrial uses of foodgrains. With some analysis based on these considerations, the National Commission on Agriculture arrived at an overall allowance of 19.0 percent for seed, feed, industrial use, and wastage for the year 2000 (India, Ministry of Agriculture 1976).

In spite of various recommendations by the National Commission on Agriculture and other committees, these data have not been updated. However, a recent survey in Punjab, Haryana, and western Uttar Pradesh (Bansil 1989) concluded that in this region the overall allowance for seed, feed, and wastage works out to about 10.0 percent. In a recent study, Tyagi (1990) showed that as the seed rate is now much lower than before and the allowance for feed and wastage remains unchanged, the actual per capita availability in recent years may have been larger than is shown by the ministry's figures. There is, however, reason to believe that the requirements for feed, particularly in the poultry and dairy sectors, have increased, though the exact magnitude of the increase on an all-India basis is not known. Therefore the ministry's figures on net production and per capita availability have been directly utilized in the analysis of past trends in this report. The following procedure has been adopted for future projections.

### Seed

In the present study, the requirements of seeds have been estimated on the basis of the projected area under each crop, and the expected seed rates have been derived from the National Commission on Agriculture report (India, Ministry of Agriculture 1976). These work out as shown in Table 36, with a total seed requirement of 5 million tons.

### Feed

Between 1970/71 and 1984/85 the output of livestock products increased at an average rate of 4.33 percent a year from 3.10 million tons to 5.61 million tons, as expressed in livestock output units (Table 37). During this period, population increased

**Table 36—Projected crop area and seed requirements for year 2000**

| Crop | Projected Area | Seed Requirement per Hectare | Total Seed Requirement |
|---|---|---|---|
| | (million hectares) | (kilograms) | (million metric tons) |
| Paddy | 41.88 | 30 | 0.84[a] |
| Wheat | 32.42 | 75 | 2.43 |
| Coarse grains | 35.25 | 15 | 0.53 |
| Pulses | 25.30 | 50 | 1.27 |
| Total | 134.85 | . . . | 5.07 |

Source: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Report of the National Commission on Agriculture,* part 3 (Delhi: Controller of Publications, 1976).

[a] In terms of rice.

**Table 37—Output of livestock products, 1970/71 and 1984/85**

| | 1970/71 | | 1984/85 | |
|---|---|---|---|---|
| Product | Actual | In Terms of LOU[a] | Actual | In Terms of LOU[a] |
| | (million metric tons) | | | |
| Meat | 0.69 | 0.69 | 1.19 | 1.19 |
| Milk | 21.71 | 2.17 | 38.80 | 3.88 |
| Eggs | 0.24 | 0.24 | 0.54 | 0.54 |
| Total | . . . | 3.10 | . . . | 5.61 |

Source: Based on data from India, Planning Commission, *The Seventh Five-Year Plan: 1985-90* (Delhi: Controller of Publications, 1985).

[a] LOU = livestock output units, obtained by adding output of meat, one-tenth of milk output, and the weight of eggs estimated at 40 grams per egg.

at a rate of 2.26 percent, the per capita income increased at 1.56 percent, and the per capita output of livestock products increased at 2.02 percent. The 1984/85 base-level feed use of foodgrains is estimated at 11.22 million tons based on a feeding ratio of 2:1; this amounts to 7.70 percent of the foodgrain production.

The feeding ratio (that is, the quantity of feed [foodgrains] required to produce one unit of livestock products) is projected to increase from 2.00 in 1984/85 to 2.40 in 2000 (the current developing-country average), an annual increase of 1.21 percent given the increasing demand, increased modernization of livestock production, and near exhaustion of available crop residues. The income elasticity of livestock demand has been assumed to be 0.9 based on Sarma (1986) and Paulino (1986). On the basis of the above assumptions, feed requirements are expected to increase at 5.95 percent a year on the assumption that the entire demand for livestock products will be met from domestic production. The relevant parameters are given below:

| | |
|---|---|
| Growth in per capita income assumed in the Perspective Plan, 1985-2000 | = 3.10 percent/year; |
| Income elasticity of demand for livestock products | = 0.9; |
| Rate of growth in per capita demand for livestock products | = 2.79 percent/year; |
| Rate of growth in feeding ratio | = 1.21 percent/year; |
| Population growth rate | = 1.84 percent/year; and |
| Rate of growth of feed use | = 5.95 percent/year. |

On this basis the estimated demand for feed in 2000 works out to 26.69 million tons under the Perspective Plan income growth rates. One advantage of this method is the possibility of estimating feed use under alternative income growth assumptions. The demand for feed works out to 21.77 million tons under continuation of past income growth, 29.14 million tons under the first accelerated growth rate scenario, and 34.50 million tons under the second accelerated growth rate scenario.[18] Due to data limitations, it was not possible to work out the effect of changes in income distribution on the feed requirements.

### Wastage and Industrial Use

A combined allowance of 12.5 million tons is made for wastage (7.5 million tons) and industrial use (5.0 million tons) in 2000. This is close to the 8-9 million tons for wastage and 5 million tons for industrial use assumed by the National Commission on Agriculture.

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[18] The last two estimates assume rapid growth in livestock output to meet the increased demand under the first and second accelerated growth rate scenarios. If livestock production falls short of demand, the gap may need to be met through import of these livestock products instead of feedgrains.

### Overall Allowance

The overall requirements for seed, feed, industrial use, and wastage allowance work out to 44.2 million tons or roughly 20.1 percent of gross production under the scenario of Perspective Plan income growth rates. A breakdown of these requirements by crop is given in Table 38. These estimates are comparable to the estimates of the National Commission on Agriculture.

The projections reflect a substantial increase in the derived demand for feed, assuming the rapid increase in the demand for livestock products if per capita income growth accelerates. A word of caution is, however, in order. In the absence of reliable base level data, the projections are rough estimates, and several of the allowances are not based on as firm a foundation as desirable. There is an urgent need for more studies of what these requirements are and how they are likely to change over time.

## Table 38—Requirements for seed, feed, industrial use, and wastage allowance for year 2000, by crop

| Crop | Seed | Feed | Industrial Use and Wastage | Total Requirements | Gross Production | Total Requirements as Share of Gross Production |
|---|---|---|---|---|---|---|
| | | | | (million metric tons) | | |
| Rice | 0.84 | 6.09 | 5.00 | 11.93 | 84.72 | 14.09 |
| Wheat | 2.43 | 8.19 | 5.00 | 15.62 | 86.74 | 18.01 |
| Coarse grains | 0.53 | 11.79 | 1.62 | 13.94 | 34.47 | 40.44 |
| Pulses | 1.27 | 0.62 | 0.81 | 2.70 | 13.45 | 20.07 |
| Total foodgrains | 5.07 | 26.69 | 12.43 | 44.19 | 219.38 | 20.14 |

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RESEARCH REPORT

82

# AGRICULTURAL GROWTH AND STRUCTURAL CHANGES IN THE PUNJAB ECONOMY: AN INPUT-OUTPUT ANALYSIS

G. S. Bhalla
G. K. Chadha
S. P. Kashyap
R. K. Sharma

August 1990

INTERNATIONAL
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# FOREWORD

This research report is part of IFPRI's continuous efforts to understand the relationship between technological change in agriculture and overall economic growth that expands employment and income opportunities for the poor in developing countries. The research is a collaborative effort with the Centre for the Study of Regional Development at Jawaharlal Nehru University in New Delhi.

The study documents and analyzes the structural changes that have occurred in the Punjab economy since the green revolution of the mid-1960s. With two input-output tables—one for 1969/70 and the other for 1979/80—the authors have traced the sources of structural changes and examined the changes in the intersectoral linkages and the quantum of indirect and induced income and employment generated by different sectors. Thus the study provides information and critical understanding required to develop programs that enhance the sectoral income and employment multipliers.

The study highlights changes in the relative importance of the primary, secondary, and tertiary sectors in the economy of Punjab in the wake of improvements in agricultural production technology. It also brings out significant structural changes within these sectors. For instance, within the primary sector, the relative share of crop production has declined, whereas that of animal husbandry has increased. Similarly, within manufacturing a notable change has been the emergence of machine- and metal-based industries. These changes are reflected in the operation of the economy at a higher technological level and in the increased labor productivity in most sectors.

Pointing to the large public investment in rural infrastructure that both preceded and followed the introduction of the new agricultural technology, the authors conclude that while the primary importance of agricultural development cannot be denied, its success is by no means independent of other factors.

It is notable that the agricultural breakthroughs in Punjab stimulated growth in other sectors of the economy, but not as much as had resulted from similar breakthroughs in other regions or countries, perhaps because of the large net outflow of capital from Punjab. This observation raises important issues on the role of further agricultural growth as well as the problem of interregional disparities and how best to deal with them.

Just Faaland

Washington, D.C.
August 1990

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Any errors and omissions that remain are the sole responsibility of the authors.

# 1

# SUMMARY

This report analyzes the structural changes that have taken place in the Punjab economy as a consequence of rapid economic growth since the introduction of the new seed-fertilizer agricultural technology during the mid-1960s. The report also attempts to identify the contribution made by agriculture in the growth process of the state.

Agriculture has been a vibrant sector in the state, thanks to large investments undertaken in irrigation both before and after independence in 1947. But the introduction of seed-fertilizer technology during the mid-1960s brought about a qualitative change and led to unprecedented growth in agricultural output, particularly for wheat and rice. Because of close input, output, and consumption linkages, rapid agricultural growth was accompanied by even faster growth in the secondary (industrial) and tertiary (service) sectors. Consequently, both total and per capita incomes have increased rapidly. With the state income rising at an annual rate of 5.0 percent from 1960/61 to 1983/84, the primary (mainly agricultural) sector recorded an annual growth rate of 4.5 percent, the secondary sector grew at 5.6 percent a year, and the tertiary sector at 6.8 percent. These growth rates were significantly higher than those registered by the rest of the country.

Some of the structural changes that have taken place in the Punjab economy consequent to its rapid growth are worth noting. First, even though the primary sector continues to dominate the Punjab economy to a much greater extent than it does the country as a whole, the economy is undergoing a perceptible process of diversification. Whereas the share of the primary sector declined from 59.9 percent in 1960/61 to 50.0 percent in 1983/84, that of the secondary sector increased from 14.6 to 17.2 percent, and that of the tertiary sector from 25.4 to 32.8 percent during the same period.

Second, the new technology has resulted in phenomenal increases in wheat and rice yields. This, in turn, has made wheat and rice the dominant crops in the state, accounting for nearly 60 percent of the total gross cropped area. Modernization and adoption of new technology has necessitated an increasing use of intermediate nonagricultural inputs in the production process, thus strengthening the intersectoral linkages.

Further, because of the increasing use of intermediate inputs in agricultural production, value added as a proportion of value of output has tended to decline. Important changes have also taken place in the relative shares of factor incomes in value added in agriculture. In particular, the share of interest and depreciation as a proportion of value added has tended to grow because of increasing use of capital in the production process.

The new seed-fertilizer technology in wheat (and later in rice) was no doubt exogenous to start with. But a noteworthy achievement in Punjab was the rapid process of internalization of this technology and its successful exploitation by Punjab farmers. The most crucial element in making this possible was large public investment in irrigation and power, scientific research, extension services, roads, markets, and other rural infrastructure. Because of assured profitability of the new technology, public investments in infrastructure were supplemented by large private investments. Along with improved agriculture, important technological improvements have also taken place in some manufacturing lines because of upgraded skills, use of power, and general improvements in infrastructure.

Manufacturing continues to be dominated by agroprocessing industries, with textiles accounting for about one-fourth of total manufacturing activity in both value of output and value added. This is followed by other agriculture-based industries, particularly food processing and dairying. However, a notable change is that basic metal industries, metal products, manufacture and repair of vehicles, and bicycles and parts had by 1979/80 become fairly important manufacturing sectors in Punjab. The emergence of machine-based and metal-based industries reflects the deepening industrial structure of the state.

Because of the much higher level of agricultural output and manufacturing activity, trade and transport and other services such as public administration and banking and insurance have significantly increased their share in the state economy. The Punjab economy, which continues to be dominated by agriculture and agriculture-based industries, is showing signs of a slow and gradual transition toward a more diversified economy.

An analysis of intersectoral linkages in the Punjab economy shows that a higher use of intermediate inputs in agriculture has led to more roundabout methods of production and much larger direct and indirect increases in the demand for nonagricultural inputs and generation of significant linkages. But the total effect of direct, indirect, and induced demand on the Punjab economy is considerably reduced because of large-scale imports of intermediate inputs and consumption goods. The incremental direct and indirect output requirements from the domestic economy are notably smaller in Punjab than in India as a whole because of the high level of imports of industrial goods. The gains of the "green revolution" in Punjab are, therefore, increasingly shared with the rest of the country. This is evident from the considerable number of workers who come from outside the state during the planting and peak harvesting seasons.

A comparison of 1969/70 and 1979/80 input-output tables brings out some of the changes that have taken place in the disposal of gross domestic product (GDP) at market prices among various elements of final demand during this period. Consumption remains the most important activity, accounting for nearly 60 percent of gross domestic expenditures during both 1969/70 and 1979/80. A significant change is a marked increase in the share of gross fixed capital formation in GDP during 1979/80 compared with 1969/70. Another notable feature of the Punjab economy is that despite very large imports of industrial products as inputs for the agricultural and manufacturing sectors and for final consumption, the increasing exports of wheat, rice, and cotton and of some agroprocessing and other industries have made it a highly export-surplus economy. Whereas substantial resources were transferred to Punjab for both rehabilitation and infrastructural investment for a number of years after independence, there is evidence to suggest that considerable savings from the Punjab economy have been used for investment outside the state since it became surplus in agricultural production. A major challenge for policymakers is to create a climate that encourages the investment of these savings within Punjab, thereby accelerating the growth rate of the secondary and tertiary sectors.

An analysis of forward and backward linkages among various sectors in the Punjab economy shows that some important changes have taken place in the nature and number of these linkages. During 1969/70, only the agricultural sectors, including animal husbandry, and some agroprocessing sectors were generating high forward and backward linkages on account of income and wage income with and without import leakages. During 1979/80, many more sectors joined this group (when linkages are considered without or with import leakages), indicating that the economy was functioning at a higher technological level. The important new sectors with import leakages are some machine-based and metal-based industries on the one hand, and trade and transport, other services, banking, and real estate on the other.

The multiplier analysis further confirms that important changes took place in the structure of the Punjab economy during 1969/70-1979/80. For example, in 1969/70, it was primarily the agriculture-based industries that recorded the highest indirect income and employment. In 1979/80, in addition to these, other industries such as basic metals, metal products, other chemicals, machine goods, electrical and nonelectrical machinery, and drugs and pharmaceuticals also began to show high indirect income and employment levels. It is also found that, since major economic activity is devoted to meeting the consumption needs of the Punjab population, those sectors that have an important place in the consumption basket have very high induced incomes.

The rapid growth and structural transformation of the Punjab economy has taken place primarily as a result of technological breakthroughs in agriculture. The Punjab experience underlines that in an agriculture-dominant, labor-surplus economy, rapid growth in agriculture has widespread effects and can become a powerful instrument for marked acceleration of the overall growth of the economy.

The Punjab experience also emphasizes that it is possible for a region within a large country to enjoy the fruits of specialization and comparative advantage in a constrained "open" economy context. Punjab was able to derive the maximum benefits of specialization in agriculture because, being a state of India, it could freely export its agricultural surpluses at favorable prices, import modern agricultural and industrial inputs from the rest of India, and attract a large number of agricultural laborers from other Indian states.

# 2

# GROWTH OF THE PUNJAB ECONOMY SINCE 1960/61

Input-output analysis is a powerful tool for understanding the structural features of an economy and baring the underlying intersectoral linkages in it. The existence of two input-output tables for Punjab, one for 1969/70 (Alagh, Bhalla, and Kashyap 1980, 104-113) and the other for 1979/80 (Appendix 1, Table 44), should be helpful for understanding not only the structural features but also the changes that have taken place in the Punjab economy over this period. However, by its very nature, an input-output table is a snapshot of an economy at a point of time. Although a comparison of the two snapshots can certainly provide some understanding of structural changes, it fails to give any insight on the dynamics of change during this period. In order to provide a background for further analysis and to fully appreciate the nature of these changes, the pattern of sectoral growth is reviewed by examining the behavior of the net state domestic product by industry of origin between 1960/61 and 1983/84.

## Overall Growth

Punjab is one of the smallest states of India, accounting for 1.65 percent of the country's area and about 2.45 percent of its population. This state bore the main brunt of the partition of India in 1947. However, within a few years after this shattering experience, Punjab was able not only to rehabilitate its economy but also to emerge as the richest state in India. By 1983/84, the per capita income in Punjab was 3,560 rupees (Rs) compared with a national average of Rs 2,288. Table 1 shows several features of the remarkable rate of growth since 1960. First, as a result of an annual growth rate of about 5 percent in net state domestic product during 1960/61-1983/84, the per capita income recorded a growth of nearly 3 percent a year and almost doubled over this period.[1] During the same period, national income and per capita income in the country as a whole grew at annual rates of nearly 3.5 and 1.3 percent, respectively.

Second, although all sectors of the Punjab economy have been growing at impressive rates, growth has been particularly high in the secondary and tertiary sectors; for example, during 1960/61-1983/84 the primary sector grew at an annual rate of 4.1 percent, while the secondary sector had a growth rate of 5.6 percent and the tertiary sector, 6.8 percent.[2] The respective growth rates of these sectors at the national level

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[1] Since the Punjab was reorganized in 1966/67, time series data on state income are available only from 1966/67 onward. The Economic Adviser to the Government of Punjab has given a figure for 1960/61, but NSDP figures for 1960/61-1965/66 have not been estimated. In addition, all data up to 1969/70 are at 1960/61 constant prices and the later data are at 1970/71 constant prices. In view of this, it is difficult to obtain exact growth rates for the entire period 1960/61-1983/84. An attempt has been made to convert the 1960s figures to 1970/71 constant prices, but the limitations of this exercise are worth noting. Growth rates from 1970/71 to 1983/84 are more reliable for this reason.

[2] The three sectors of the economy are defined as follows: Primary—agriculture; animal husbandry; forestry and logging; fishing; and mining and quarrying; Secondary—manufacturing; construction; and electricity, gas, and water supply; Tertiary—transport, storage, and communications; trade, hotels, and restaurants; banking and insurance; real estate and ownership of dwellings; public administration and defense; and other services. To simplify the text, all subsectors within these categories are also referred to as sectors throughout the report.

**Table 1—Net state domestic product at factor cost, by industry of origin, 1960/61-1983/84**

| | | | | | | Growth Rate | |
|---|---|---|---|---|---|---|---|
| Industry | 1960/61 | 1969/70 | 1970/71 | 1979/80 | 1983/84 | 1960/61-1983/84 | 1970/71-1983/84 |
| | | | (Rs million)[a] | | | (percent) | |
| Agriculture[b] | 4,532 | 6,687 | 6,212 | 8,188 | 9,153 | 3.3 | 3.6 |
| Livestock | 744 | 1,672 | 2,131 | 3,352 | 3,830 | 6.9 | 4.6 |
| Forestry | 16 | 26 | 30 | 58 | 68 | 6.6 | 9.1 |
| Fishery | 4 | 5 | 5 | 8 | 10 | 4.2 | 5.2 |
| Mining and quarrying | 1 | 2 | 5 | 2 | 4 | 5.7 | 2.5 |
| Subtotal: primary sector | 5,297 | 8,392 | 8,382 | 11,607 | 13,065 | 4.1 | 4.9 |
| Registered manufacturing | 287 | 582 | 567 | 1,235 | 1,600 | 7.8 | 5.7 |
| Unregistered manufacturing | 355 | 570 | 582 | 1,028 | 1,287 | 6.7 | 7.8 |
| Construction | 608 | 896 | 938 | 889 | 1,258 | 2.4 | 4.5 |
| Electricity | 42 | 113 | 112 | 264 | 350 | 9.1 | 9.8 |
| Subtotal: secondary sector | 1,292 | 2,161 | 2,199 | 3,416 | 4,494 | 5.6 | 7.1 |
| Transport and storage | 321 | 442 | 503 | 908 | 1,138 | 6.6 | 6.8 |
| Trade and hotels | 1,003 | 1,770 | 1,803 | 2,874 | 4,228 | 6.7 | 7.9 |
| Banking and insurance | 125 | 212 | 231 | 447 | 737 | 8.1 | 9.8 |
| Real estate and dwellings | 215 | 228 | 230 | 227 | 360 | 2.0 | 4.1 |
| Public administration | 137 | 273 | 317 | 563 | 925 | 8.6 | 9.8 |
| Other services | 447 | 672 | 697 | 1,129 | 1,182 | 4.6 | 4.2 |
| Subtotal: tertiary sector | 2,247 | 3,597 | 3,780 | 6,149 | 8,570 | 6.8 | 7.3 |
| Net state domestic product | 8,836 | 14,151 | 14,362 | 21,172 | 26,130 | 4.9 | 5.4 |

Sources: Based on data from Punjab, *The Statistical Abstract of Punjab*, various issues (Chandigarh: Economic and Statistical Adviser, various years).

Note: Parts may not add to totals because of rounding.

[a] In 1970/71 prices.

[b] Refers to crop production only.

were 2.2, 4.2, and 5.0 percent. Thus, while the rate of growth in the primary sector in Punjab was nearly double that of India, growth rates in the secondary and tertiary sectors were nearly one and a half times higher. Further, although the growth of the primary sector in Punjab was substantially lower than that of the other sectors, it is quite impressive when compared with other low- and middle-income countries (see Westley 1986). The various sectors within the primary, secondary, and tertiary sectors, however, recorded varying rates of growth. For example, within the primary sector, income from agriculture grew at an annual rate of 3.3 percent and that from livestock at about 7.0 percent. Within the secondary sector, income from electricity grew at the rate of 9.1 percent and from manufacturing at slightly more than 7.0 percent.

Third, because of the differential rates of growth in the three sectors, their respective shares in the total net state domestic product underwent a significant change. During 1960/61-1983/84 the share of the primary sector, when measured in 1970/71 constant prices, declined from 59.9 percent of the state income to 50.0 percent. The share of agriculture declined from 51.3 percent to only 35.0 percent. On the other hand, during the same period the share of the secondary sector increased from 14.6 percent to 17.2 and that of the manufacturing sector from 7.3 percent to 11.0 percent. A notable shift was in the share of the tertiary sector in the net state domestic product, which rose from 25.4 percent in 1960/61 to 32.8 percent in 1983/84. The changes in the shares of different sectors are more pronounced when calculated at current prices. Despite the rapid growth of the primary, secondary, and tertiary sectors, the primary sector continues to dominate the Punjab economy to a much greater extent than it does the country as a whole. Thus, for India during 1983/84, the primary sector accounted for only 40.9 percent of total income compared with 50.0 percent for Punjab, while the secondary and tertiary sectors' contribution to national income, at 20.6 percent and 38.5 percent, respectively, was much greater than their contribution in Punjab. Nevertheless, it is obvious that the Punjab economy is undergoing a process of sectoral diversification in terms of income generated by various sectors. This sectoral diversification in income shares has not been accompanied by a commensurate diversification of the work force. In fact, the proportion of the male work force engaged in agriculture increased substantially from 56.2 percent in 1961 to 63.6 percent in 1971. Only during 1971-81 was there a small decline in the male work force in agriculture (India, Ministry of Home Affairs 1982) to 60.0 percent in 1981.

Fourth, all three sectors have contributed to the growth of the economy. However, since a high proportion of state income has always come from the primary sector, the growth of this sector has directly and indirectly been the main engine of growth in the state. For instance, out of a total increase of Rs 17,293.3 million in state income between 1960/61 and 1983/84, Rs 7,768.6 million (as much as 44.9 percent) was provided by the primary sector.

Finally, as a consequence of the introduction of new seed-fertilizer technology during the mid-1960s, the growth rate of state income and of the primary, secondary, and tertiary sectors accelerated appreciably during 1970/71-1983/84. Since the thrust of economic development in the state has been provided by the agricultural sector, a detailed discussion of its performance is undertaken next, followed by a brief discussion of the growth of the secondary and tertiary sectors of the economy.

## Growth and Transformation of Punjab Agriculture

Punjab has recorded a very high rate of growth in agriculture since the inception of planning in 1950/51.[3] It was during the 1950s that the basic institutional and economic infrastructures were created in agriculture through land reforms and massive public investments. These investments were made in development of irrigation and electric power, foundation of agricultural research and extension services, strengthening of the cooperative credit structure, and expansion of markets. Simultaneously, land reform legislation was passed and put into effect. Although land reforms were halfhearted and failed to bring about any perceptible improvement in the distribution of landownership, they did succeed in abolishing the intermediaries and reducing the incidence of tenancy, thereby facilitating consolidation of holdings. These developments during the early postindependence years laid the foundations for rapid growth and modernization of agriculture. Because of large-scale investment in irrigation and other rural infrastructure as well as changes in institutional structure, Punjab was able to record an agricultural growth rate as high as 4.6 percent during 1950/51-1964/65—long before the onset of the "green revolution." Both area expansion and yield increases contributed to this growth.

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[3] During 1952/53-1964/65, Punjab led the other states in growth rates of total agricultural output and of individual crops such as wheat, rice, and cotton. This was not the case, however, in relation to growth of productivity. For example, during this period the Punjab trailed Gujarat, Madras, and Mysore in the growth of overall productivity; Gujarat, Madras, Mysore, Andhra Pradesh, and Kerala in the growth of foodgrain productivity; and Mysore, Maharashtra, and Andhra Pradesh in the growth of nonfood productivity (see India, Ministry of Food and Agriculture 1968).

The introduction of the new seed-fertilizer technology in the mid-1960s marked the beginning of a new chapter in the history of Punjab agriculture. Under the impact of technological improvements from the late 1960s, there appears to have been an unparalleled rise in agricultural production and productivity. The state is now universally acknowledged as the heartland of the green revolution. Information on area, output, and yield levels for important crops and on total agricultural output from 1950/51 to 1984/85 is given in Table 2. Figures 1 and 2 illustrate the rapid strides made by agriculture in the state. Some of the salient features are described below.

First, with adoption of the new production technology during the late 1960s there was a remarkable expansion of area under wheat and rice, while the cultivation of most other crops (for which there was a conspicuous absence of improved technology) registered a slow but persistent decline. It was the technology-price-profitability advantage of rice and wheat over other crops that was reflected in differential growth in area and output of various crops. Thus the share of wheat area in the gross cropped area, which had increased from 26.9 percent in 1950/51 to 30.6 percent in 1964/65, grew to 44.1 percent by 1984/85. Rice, which had accounted for only 2.9 percent of gross cropped area in 1950/51 and 5.0-6.0 percent in 1964/65, increased its share to 23.4 percent by 1984/85. For most other crops, cropped area declined in varying degrees after the onset of the wheat and rice revolution in the late 1960s, most significantly in the case of pulses (gram), coarse cereals, and groundnuts.

Second, as expected with improved technology, yield rates grew impressively in rice and wheat compared with most other crops. Wheat yields, which had grown by 2.0 percent a year during 1952/53-1964/65, grew by 2.6 percent a year during 1967/68-1984/85. The growth rate for rice was even more phenomenal, increasing from 1.7 percent a year in the pre-green-revolution period to 5.7 percent in the post-1967 years. Consequently, whereas yield increase had accounted for nearly 37 percent of the growth of wheat output in the pre-green-revolution period, its contribution to the growth of output increased to nearly half in the post-green-revolution years. In the case of rice, the contribution of yield to growth of output increased from nearly 20 percent to 35 percent during this period. For other crops, with the exception of sugarcane, there was hardly any increase in yield levels. However, because of the predominance of wheat and rice, the overall productivity of all crops taken together grew at an impressive rate, and yield increases emerged as the predominant source of growth of total agricultural output in Punjab.

Third, as a result of rapid growth in both area and yield, the output growth for wheat and rice since the late 1960s has been dramatic. Wheat output, which was a bare 1.0 million metric tons in 1950/51, rose to 2.4 million tons in 1964/65 but reached a level of 10.2 million tons in 1984/85.[4] The production of rice, which was hardly a popular crop in Punjab until the late 1960s, increased from 0.1 million tons in 1950/51 to 0.5 million tons in 1969/70, then rose to 5.1 million tons in 1984/85. By 1984/85, these two crops had become the predominant crops of the state and accounted for the major proportion of the total value of agricultural output. The expansion in area under wheat and rice, for which new technology was available, not only necessitated increasing purchases of modern inputs from other sectors of the domestic economy and from outside the state, but also generated increasing levels of marketable surpluses of these crops. As a result, Punjab agriculture became increasingly commercialized and interlinked with the national market.

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[4] All tons in this report are metric tons.

## Table 2—Area, output, yield, and growth rates of principal crops of Punjab, 1950/51-1984/85

| Year | Rice | | | Wheat | | | Gram | | | Oilseeds | | | Sugarcane | | | Cotton | | | Gross Cropped Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area[a] | Output[b] | Yield[c] | Area[a] | Output[b] | Yield[c] | Area[a] | Output[b] | Yield[c] | Area[a] | Output[b] | Yield[c] | Area[a] | Output[b] | Yield[c] | Area[a] | Output[b] | Yield[c] | |
| 1950/51[d] | 120 | 107 | 892 | 1,137 | 1,024 | 901 | 851 | 511 | 600 | 128 | 55 | 430 | 91 | 2,570 | 28,240 | 225 | 43 | 192 | 4,224 |
| 1960/61[d] | 227 | 229 | 1,009 | 1,400 | 1,742 | 1,244 | 838 | 681 | 813 | 185 | 121 | 654 | 133 | 4,860 | 36,540 | 447 | 121 | 269 | 4,723 |
| 1964/65[d] | 287 | 351 | 1,223 | 1,563 | 2,360 | 1,510 | 744 | 666 | 895 | 239 | 222 | 929 | 122 | 4,440 | 36,390 | 487 | 138 | 282 | 5,113 |
| 1967/68 | 314 | 415 | 1,322 | 1,790 | 3,335 | 1,863 | 530 | 452 | 853 | 399 | 314 | 987 | 137 | 4,800 | 35,070 | 419 | 132 | 315 | 5,441 |
| 1969/70 | 359 | 535 | 1,490 | 2,166 | 4,865 | 2,246 | 380 | 393 | 1,034 | 294 | 213 | 724 | 149 | 6,180 | 41,480 | 409 | 145 | 353 | 5,499 |
| 1979/80 | 1,167 | 3,041 | 2,606 | 2,823 | 7,896 | 2,797 | 236 | 162 | 686 | 199 | 157 | 789 | 77 | 3,930 | 51,040 | 630 | 205 | 326 | 6,535 |
| 1984/85 | 1,644 | 5,054 | 3,074 | 3,094 | 10,176 | 3,289 | 102 | 60 | 1,589 | 198 | 199 | 1,004 | 79 | 4,920 | 62,260 | 472 | 210 | 446 | 7,013 |
| Growth rates (percent/year) | | | | | | | | | | | | | | | | | | | |
| 1952/53-1964/65[d] | 6.82 | 8.68 | 1.74 | 3.34 | 5.38 | 1.98 | 2.11 | 1.26 | −0.83 | 3.27 | 6.13 | 2.77 | 4.61 | 6.72 | 2.01 | 4.68 | 7.06 | 2.28 | 1.19 |
| 1967/68-1984/85 | 10.87 | 16.46 | 5.71 | 2.80 | 5.51 | 2.64 | −7.45 | −10.63 | −2.96 | −3.29 | 0.22 | 3.53 | −4.28 | −4.03 | 0.24 | 2.99 | 2.01 | −0.96 | 1.72 |

Sources: For 1952/53-1964/65 growth rates, India, Ministry of Food and Agriculture, Directorate of Economics and Statistics, *Growth Rates in Agriculture, 1949-50 to 1964-65* (Delhi: Manager of Publications, 1968); for 1967/68-1984/85, statistical function of the type $Y = AB^t$ was fitted to time series of yearly data drawn from Punjab, *The Statistical Abstract of Punjab*, various issues (Chandigarh: Economic and Statistical Adviser, various years).

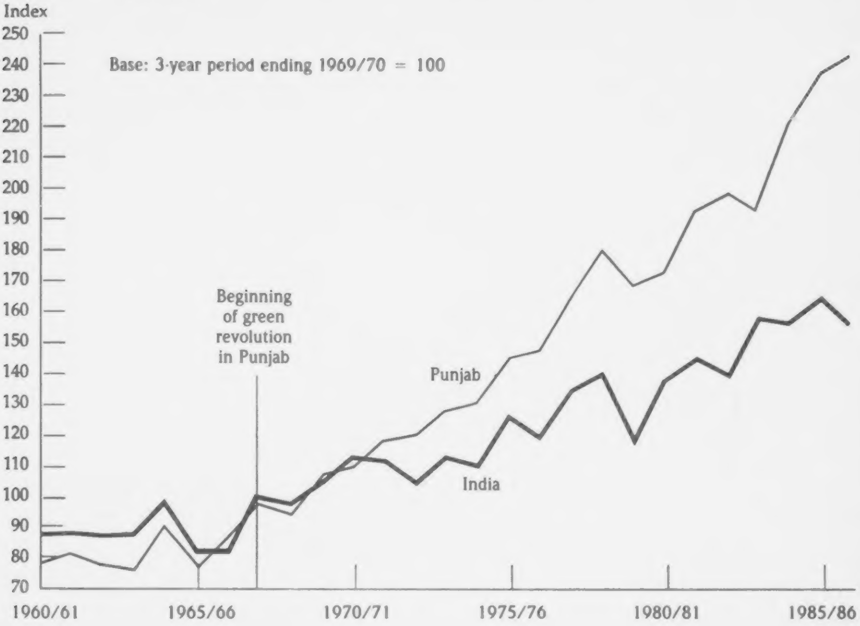
[a] In 1,000 hectares.

[b] in 1,000 metric tons.

[c] In kilograms per hectare.

[d] Refers to former Punjab that is present Punjab, Haryana, and parts of Himachal.

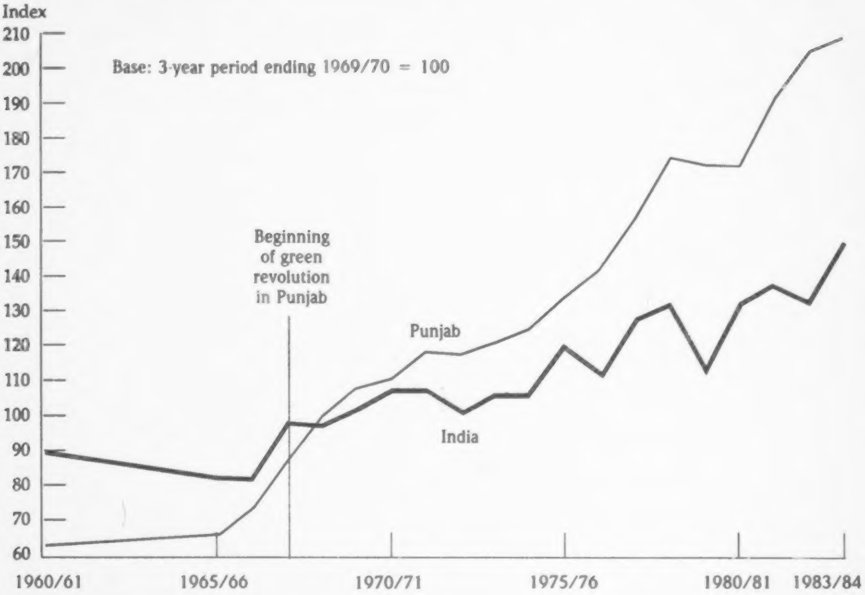
Figure 1—Index of agricultural production: India and Punjab, 1960/61-1986/87



Finally, because of the rapid rate of growth of 6.9 percent a year recorded by animal husbandry (livestock) during 1960/61-1983/84, significant diversification took place within the agricultural sector. In 1960/61, livestock accounted for only 14.1 percent of total income generated in agriculture (that is, crop production plus livestock); its share increased to 25.5 percent in 1970/71 and to 29.5 percent by 1983/84. This remarkable growth of animal husbandry was made possible by large-scale adoption of new technology for crop production in general, and for rice and wheat in particular. Since the essence of the new technology lies in the introduction of short-duration crops, it proved to be highly land-augmenting. Consequently, at the same time as the rapid expansion of area under wheat and rice, it became possible to bring a larger area under fodder cultivation. Further, with the development of irrigation, the area under green fodder increased rapidly. Per hectare productivity of green fodder also increased because of the introduction of modern seed-fertilizer technology in fodder production.

As will be discussed later, the number of bullocks per hectare of cropped area dropped significantly as a result of rapid tractorization in Punjab, resulting in a significant decline in the demand for fodder for draft animals. With the given land base, cultivators were able to sustain a larger number of milch animals in place of draft animals. The rapid increase in the number of milch animals and in milk production was made possible by development of infrastructure such as roads, transportation, veterinary services, milk-collecting booths, chilling centers, and dairies. With a rapid increase in per capita income, the consumption of milk and milk products increased sharply and

Figure 2—Index of agricultural productivity: India and Punjab, 1960/61-1983/84



Note: Productivity is per hectare of net sown area.

milk production became a fairly profitable allied agricultural activity. Milk production continues to be a part-time household activity characterized by strong production and demand linkages.

## Main Determinants of Agricultural Growth

Punjab agriculture has recorded a phenomenal growth and has undergone a radical transformation since the mid-1960s. This transformation can be explained only in terms of a combination of several institutional, infrastructural, and technological factors, along with the considerable initiative shown by self-cultivating farmers in adopting the new technologies.

### Institutional Factors

One of the important reasons for the agricultural transformation in Punjab has been the existence of a relatively more favorable institutional structure than is found in many other parts of the country. Under the traditional Mahalwari system of land settlement, land rights were vested primarily in the cultivating castes of the village communities. Despite dilution of the system during the British period, largely through conferment of superior land rights on a select few, self-cultivators continued to be an important component of the agrarian scene in Punjab. Partition and the consequent refugee resettlement led to the breakup of some large estates of former landlords who migrated to Pakistan and the allotment of this land to in-migrant cultivators on a much-reduced scale. The various land reform laws, despite their limitations, resulted in the emergence of self-cultivation as the predominant mode of production. In 1953/54, in United Punjab (comprising the present Punjab, Haryana, and parts of Himachal Pradesh) about 60.0 percent of net operated area was under self-cultivation; by 1971/72 this had risen to 74.2 percent.

### The Role of Infrastructure

Development of infrastructure has played a major role in the agricultural transformation of Punjab. The state enjoyed an initial advantage in irrigation development, as large-scale investments in canal irrigation had been undertaken by the colonial government during the last part of the nineteenth century and the early twentieth century. Thus, on the eve of independence in 1947, East Punjab (the present Punjab, Haryana, and parts of Himachal Pradesh) had about 33 percent of its area irrigated, compared with only 18 percent for the country as a whole (Hirashima 1978).

With the launching of planned development in 1951, the policymakers in India gave high priority to investment for the development of rural infrastructure. In Punjab the plan strategy consisted of developing agriculture—the most dominant sector—along with a network of small-scale agroprocessing, agro-input, and consumer goods industries. The policymakers were keenly aware of the importance of irrigation and other rural infrastructure such as power, credit, roads, markets, research, extension, and rural education for rapid development of agriculture and allied industries.

It is significant that Punjab was able to maintain a high level of per capita development expenditure during the entire planning period. In terms of plan outlay, the state occupied the top position during the first three plan periods (1951-66) and has since been in second place among all the major states of India. For the first three plans, this high level of expenditure was financed mainly through high levels of per capita central assistance, but it was sustained afterward through larger internal resources.

A consistent pattern of development priorities has been an important aspect of successive state plans wherein irrigation, power, agriculture, and community development together account for about 70 percent of the total plan outlay (Table 3). As a consequence, the proportion of net area irrigated increased from 49.5 percent of net area sown in 1950/51 to as much as 80.7 percent by 1980/81, compared with an increase from 17.6 percent to 27.7 percent for India as a whole. It may also be added here that the Punjab peasants have had long experience in using irrigation technology. Further, many of the immigrants came from the canal colonies of Montgomery, Lyallpur, and Sargodha after partition and brought to bear their expertise in using irrigation to augment production.

During the 1950/51-1980/81 period, the structure of irrigation changed steadily in favor of tubewells. In Punjab the net area irrigated by tubewells and wells increased from 35.8 percent in 1950/51 to 57.3 percent in 1980/81, while in India as a whole the area increased from 28.7 percent to 45.7 percent. The irrigation base of small holdings has been as good as that of the upper farm-size holdings, particularly in canal irrigation. Large-scale investments in tubewells by small farmers, combined with the widespread practice of hiring in tubewell services, have also contributed to the strength of the irrigation base in smaller holdings.

The high priority given to power in the planned development of Punjab is reflected in the per capita consumption of electricity, which increased from 5.9 kilowatt-hours in 1951 to 335.4 kilowatt-hours in 1982/83, while for India as a whole it increased from 17.8 kilowatt-hours to only 146.0 kilowatt-hours. By 1981, 100 percent of Punjab villages were electrified compared with 47.0 percent for India as a whole. By 1982/83

## Table 3—Sectoral allocation of total expenditure in the five-year plans of Punjab, 1951-56 to 1980-85

| Sectors | First Plan, 1951-56[a] | Second Plan, 1956-61[a] | Third Plan, 1961-66[a] | Fourth Plan, 1969-74 | Fifth Plan, 1974-79[b] | Sixth Plan, 1980-85 |
|---|---|---|---|---|---|---|
| | (percent) | | | | | |
| Agriculture and community development | 18.10 | 16.70 | 17.21 | 12.00 | 13.17 | 15.25 |
| Irrigation and power | 58.00 | 51.70 | 52.79 | 55.43 | 51.18 | 56.38 |
| Industries and mining | 0.90 | 3.40 | 4.06 | 3.24 | 5.00 | 4.09 |
| Transport and communication | 5.80 | 7.00 | 5.62 | 14.85 | 9.35 | 5.67 |
| Social services | 8.50 | 16.40 | 18.75 | 13.25 | 20.16 | 17.76 |
| Miscellaneous | 8.10 | 4.80 | 1.57 | 1.23 | 1.14 | 0.85 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| | (Rs million) | | | | | |
| Total expenditure | 1,409 | 1,484 | 2,520 | 4,214 | 8,132 | 20,000 |

Sources: Based on data from Punjab, *The Statistical Abstract of Punjab*, various issues (Chandigarh: Economic and Statistical Adviser, various years); and data from the first six five-year plans of Punjab.

[a] Plan relates to former (pre-1966) Punjab.

[b] Figures for 1974/75 have not been included due to lack of data.

as much as 40.7 percent of the electricity was consumed for agricultural use in Punjab, while the national consumption for agriculture was only 18.6 percent. The availability of power in rural Punjab has made possible the electrification of thousands of pump sets and tubewells. Further, it has enabled the farmers to use power threshers, sugarcane crushers, and chaff cutters on a large scale, thus making a dent in the drudgery associated with traditional operations. The use of electric bulbs and other gadgets has also helped some farmers to visibly improve their quality of life. However, despite the great increase in power, the state has had frequent power shortages and shutdowns because supply has been unable to match demand, indicating the need for an even higher level of investment.

Another important infrastructural development is the impressive increase in the provision of cooperative credit to the cultivators. The loans disbursed in Punjab increased from Rs 7 per hectare in 1951/52 to Rs 485 in 1982/83. At the national level, the increase was only from Rs 2 to Rs 131. Another promising aspect of the cooperative credit structure in Punjab is that the per hectare disbursement of short-term cooperative loans for purchase of fertilizers is fairly equitable among farms of different sizes (Chadha 1986).

In addition to short-term cooperative credit, by 1985/86 the Primary Land Mortgage Banks were advancing loans worth about Rs 500 million a year compared with only Rs 164 million advanced during 1966/67. A major proportion of these loans is used for installation of tubewells, purchase of tractors, and land improvement. The State Land Mortgage Bank also finances the purchase of tractors and tubewells by the cultivators through large annual loans.

The availability of credit for agricultural finance in India increased rapidly after the nationalization of commercial banks in 1969, and their share in both short- and long-term credit nearly doubled during 1972-81. The expansion of commercial bank credit to agriculture was extraordinary in Punjab, increasing from Rs 470 million in 1975 to Rs 7,080 million in 1986.

Punjab has also undertaken massive programs of infrastructural development in roads, extension services, agricultural research, and education. By 1985, 98 percent of all villages in the state were linked by paved roads. The surfaced road length per 1,000 population increased from 0.56 kilometer in 1960/61 to 2.20 kilometers in 1982/83 compared with the national average of 1.07 kilometers. In 1982/83, there were 73.5 kilometers of surfaced roads per 100 square kilometers of area in Punjab compared with 22.8 kilometers for India as a whole. Between 1965 and 1983, the number of passenger vehicles in Punjab increased by nearly 150 times and goods vehicles by more than 50 times. There has also been a remarkable increase in the number of regulated markets and in storage capacity. This has greatly facilitated the smooth marketing of huge surpluses of wheat and paddy during the peak harvesting season (Punjab, Economic and Statistical Adviser, various years).

The state has also tried to develop a network of extension services for agricultural development. Several programs, such as the National Extension Programme, the Panchayati Raj[5], and the Community Development Programme, were introduced during the 1950s, and as a consequence, a hierarchy of trained agricultural extension workers was created. The Punjab Agricultural University at Ludhiana has made a signal contribution in the development of new seed varieties and has been actively involved in the extension and training programs in the state.

A great deal of investment has also been made in education and health. Punjab, once educationally backward, now figures among the leading states in educational facilities at the school and university levels as well as in engineering and medicine. The state's literacy rate has also shown a sharp rise, though it lags far behind that of Kerala (Table 4).

## Table 4—Educational facilities in rural Punjab, 1966-83

| | | Rural Enrollment as a Share of Total Enrollment | | Rural Share of Total State Expenditure on Education |
|---|---|---|---|---|
| Level of Education | Year | Male | Female | |
| | | | (percent) | |
| Primary | 1966 | 87.24 | 81.58 | 96.73 |
| | 1977 | 87.50 | 87.58 | 99.62 |
| | 1983 | 87.05 | 86.02 | n.a. |
| Middle | 1966 | 82.84 | 75.67 | 90.54 |
| | 1977 | 93.34 | 91.16 | 97.67 |
| | 1983 | 80.63 | 71.75 | n.a. |
| High and higher secondary | 1966 | 36.69 | 27.57 | 66.44 |
| | 1977 | 66.57 | 60.96 | 91.11 |
| | 1983 | 56.76 | 48.29 | n.a. |
| College | 1966 | 18.55 | 12.09 | n.a. |
| | 1977 | 22.80 | 13.61 | n.a. |
| | 1983 | 22.01 | 13.80 | n.a. |

Sources: Based on data from Punjab, *Educational Statistics of Punjab,* Publication No. 333 (Chandigarh: Economic and Statistical Organization, n.d.), 116-119, 130-131, 146-147; and personal visits to the Directorate of Public Instruction, Chandigarh.

Note: n.a. means not available.

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[5] A traditional system of self-government in Indian villages. The panchayat (village council) runs the routine affairs of the village and settles many local disputes. Soon after independence the panchayats were given many additional statutory powers in matters pertaining to local development.

### Agricultural Price Policy

Another important factor in the rapid growth of agriculture in India, and particularly in Punjab, is the existence of a favorable price climate since the establishment of the Agricultural Price Commission in the mid-1960s. The commission, by its terms of reference, is expected to recommend prices for agricultural commodities that are remunerative to the cultivators and give them sufficient incentive to invest in new technology.

Most studies have shown that the minimum support prices fixed by the government on the recommendations of the commission were indeed remunerative. The establishment of the Food Corporation of India, which is required to undertake purchases of the entire market arrival of foodgrains at the minimum support prices, and the creation of market and transport infrastructure provided the assurance needed to persuade farmers to invest in new technology and thereby augment production. The Punjab farmers were the major beneficiaries of the new price policy, as they brought large surpluses of (first) wheat and (later) rice into the market and were able to obtain profitable prices for these and other commodities.

### Political Clout of Prosperous Peasantry

In Punjab, unlike many other states in India, political power has shifted decisively from the urban trading and money-lending bourgeoisie to the prosperous rural peasantry since independence. Irrespective of their political affiliation, each successive state government in Punjab has taken positive policy measures to further the interests of this section of the population. These include the rural bias in planned expenditure on infrastructure; provision of essential inputs such as water and power at highly subsidized rates; stabilization of agricultural prices; availability of cheap loans both directly and through the cooperatives; provision of inputs such as fertilizers, better seeds, and insecticides; and the organization of agricultural research and extension.

Given this infrastructure, and offered opportunities to better their lot through the adoption of new techniques, the Punjab peasants accepted the challenges by taking the necessary risks and brought about the agricultural breakthrough. The new technology was first adopted by large landholders who had the initial wherewithal and capacity to take risks, but was soon extended to peasants with smaller holdings. The profitability of the new technology prompted cultivators to make large investments in tubewells and complimentary irrigation structures in a bid to reap the technological benefits. This investment was facilitated by the availability of large amounts of subsidized institutional credit that greatly complimented the farmers' own resources.

To sum up, the Punjab has built a developed rural infrastructure over the years out of its own and central resources. In fact, the state had succeeded in creating the requisite infrastructure before full modernization commenced in the late 1960s. The availability of this well-developed infrastructural base, in conjunction with the appropriate institutional framework and a positive agricultural price policy, provides the most convincing explanation for the rapid growth of agriculture in Punjab through adoption of the new seed-fertilizer technology.

### Modern Inputs and Increasing Mechanization

Along with the use of high-yielding varieties of seeds, the rapid expansion of fertilizer application since 1965/66 is a crucial ingredient of the new technology. Fertilizer use per hectare of cropped area increased from a mere 8.8 kilograms in 1965/66 to 37.6 kilograms in 1970/71 and 149.4 kilograms in 1984/85. The fertilizers are used predominantly for wheat and rice.

Another vital aspect of technological upgrading is the increasing mechanization of agricultural operations, with rapidly expanding capital stock and its changing composition over time (Table 5). The arrival of a highly productive production technology in the mid-1960s was responsible for both inspiring and facilitating the modernization and increasing mechanization of agriculture in Punjab.

The number of tractors in the state increased by more than eleven times between 1966 and 1981 compared with an increase of three and a half times during 1956-66. The number of tubewells increased by fourteen times between 1966 and 1981, while in the pre-1966 decade they increased by only five times. There was one tubewell for every 2,222 hectares of net sown area in 1951, for every 83 hectares in 1966, and for every 7 hectares in 1981. With the rapid increase in the number of tractors, the average net sown area per tractor declined from 3,125 hectares in 1951 to 356 hectares in 1966 to only 36 hectares in 1981.

The pace of mechanization in the post-1966 era has indeed been very fast, while the use of bullocks and their importance in agriculture have been rapidly declining. Between 1951 and 1966, the number of bullocks increased by about 11 percent, while in the post-1970 years the number actually declined. Over time, the wooden plow has lost ground to the iron plow, and bullock-operated cane crushers are rapidly being replaced by power-operated ones. Threshing has been almost completely mechanized, and notable inroads have also been made by combines in the harvesting operations.

As a result of these developments, not only has mechanization increased rapidly, but the capital structure in Punjab agriculture has also undergone a significant change. The state has a disproportionately high share in the distribution of capital and other modern production assets at the national level. A number of factors have been respon-

**Table 5—Capital structure in Punjab agriculture, 1951-82**

| Item | 1951[a] | 1961 | 1966 | 1972 | 1977 | 1982 |
|---|---|---|---|---|---|---|
| Bullocks (number) | 1,378,100 | 1,455,400 | 1,533,500 | 1,669,800 | 1,580,800 | n.a. |
| Net sown area per bullock (hectares) | 2.6 | 2.6 | 2.5 | 2.5 | 2.6 | n.a. |
| Plows | | | | | | |
| Iron (number) | 153,000 | 411,815 | 634,141 | 755,171 | 906,560 | 1,074,000 |
| Wooden (number) | 667,130 | 673,835 | 699,157 | 653,642 | 602,213 | 581,200 |
| Cane crushers | | | | | | |
| Power-operated (number) | 476 | 1,566 | 3,223 | 9,500 | 16,599 | 29,500 |
| Bullock-operated (number) | 61,308 | 73,691 | 88,768 | 78,014 | 75,471 | 75,800 |
| Tubewells | | | | | | |
| Diesel engine (number) | 1,285 | 6,983 | 25,670 | 249,687 | 304,000 | 447,600 |
| Electric motor (number) | 300 | 6,565 | 20,233 | 78,763 | 196,579 | 215,000 |
| Net sown area per tubewell (hectares) | 2,222 | 277 | 83 | 12 | 8 | 6 |
| Tractors (number) | 1,148 | 4,935 | 10,636 | 41,185 | 64,307 | 106,500 |
| Net sown area per tractor (hectares) | 3,069 | 760 | 358 | 99 | 65 | 40 |

Sources: For data through 1977, Punjab, *The Statistical Abstract of Punjab,* various issues including that for 1965 pertaining to former Punjab (Chandigarh: Economic and Statistical Adviser, various years); and for 1982 data, India, Ministry of Planning, Central Statistical Organization, *Statistical Abstract* (Delhi: Controller of Publications, 1986).

Note: n.a. means not available.

[a] For some items, the 1951 figures were not available for the present Punjab. These were derived from the figures for the old Punjab under the assumption that the ratio of the 1951 figure between the present Punjab and Haryana was the same as for the 1956 figure.

sible for the rapid mechanization of agriculture in Punjab. The spurt in tubewell installation was caused by the need to increase and regulate the flow of irrigation to permit adoption of the highly profitable new technology in wheat and rice. The drive toward mechanization was necessitated mainly by the relative scarcity of labor (due to the low man-land ratio in the state) and high wage rates, particularly during peak agricultural operations. In the post-1966 years the spurt in tractors was caused by the need for both timely completion of field crop operations and relief from the pressure on labor demand. Tractors were also increasingly used for transport purposes and soon became a status symbol, driving quite a few medium and even small farmers to purchase one regardless of the size of their holding. Large-scale investment in tubewells and other farm mechanization was facilitated partly by ready availability of subsidized institutional credit and partly through remittances from abroad.

The increasing modernization of production technology in Punjab agriculture can also be seen in the composition of material inputs. Table 6 details a number of important changes for the farm sector as a whole. While the relative share of modern inputs (for example, chemical fertilizers, diesel oil, electricity) increased dramatically, that of traditional inputs (such as organic manures, bullock feed, a part of seed cost) declined steeply over time, especially after the mid-1960s. The relative share of purchased inputs also increased sharply, from about 30 percent in 1960/61 to more than 85 percent in 1980/81. Clearly, agriculture in Punjab is increasingly linked with nonagricultural sectors for the supply of its inputs. This has created expansion possibilities for such activities, both locally and outside the state.

### Changes in Factor Shares

With rapid modernization and changes in factor proportions, significant changes seem to have taken place in the shares of various factor incomes in value added through the process of agricultural production. In the absence of data on the total crop complex, the analysis of time series data undertaken here on the cost of cultivation of wheat in Punjab brings out some of these changes (Table 7). The results of trend values obtained by fitting semi-log regressions of relevant variables on time are given in Table 8. A few

**Table 6—Input structure in Punjab agriculture, 1960/61-1980/81**

| Input | Share of Input Expenditure | | | | |
|---|---|---|---|---|---|
| | 1960/61 | 1965/66 | 1970/71 | 1975/76 | 1980/81 |
| | | | (percent) | | |
| Fertilizers | 1.52 | 8.09 | 27.20 | 28.01 | 37.70 |
| Organic manures | 5.93 | 3.88 | 3.60 | 2.60 | 2.09 |
| Diesel oil | 9.24 | 13.99 | 26.53 | 35.93 | 38.73 |
| Irrigation charges | 6.62 | 6.50 | 2.71 | 1.57 | 1.03 |
| Electricity charges | 1.11 | 1.52 | 2.60 | 2.48 | 2.80 |
| Pesticides | 1.51 | 1.40 | 1.00 | 0.67 | 3.60 |
| Repair and maintenance | 5.93 | 4.71 | 4.14 | 2.62 | 2.12 |
| Seed cost | 37.44 | 37.75 | 22.00 | 15.85 | 6.33 |
| Bullock feed | 27.83 | 19.54 | 7.64 | 8.29 | 4.28 |
| Other | 2.87 | 2.62 | 2.58 | 1.98 | 1.32 |
| Total inputs | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Purchased inputs | 30.00 | 40.00 | 70.00 | 78.00 | 87.00 |
| Farm-raised inputs | 70.00 | 60.00 | 30.00 | 22.00 | 13.00 |

Source: State Income Accounts of Punjab, consulted by author in Economic and Statistical Organization, Chandigarh.

## Table 7—Value of output, factor shares in value added, and labor productivity in wheat cultivation in Punjab, 1970/71-1983/84

| Year | Value of Output | Gross Value Added | Wages | Depreciation | Interest | Surplus | Rent | Labor Productivity[a] |
|---|---|---|---|---|---|---|---|---|
| | | | | (Rs/hectare) | | | | |
| 1970/71 | 1,982.53 | 1,398.32 | 328.30 | 57.87 | 107.66 | 327.94 | 576.55 | n.a. |
| 1971/72 | 2,219.19 | 1,495.35 | 346.28 | 37.10 | 100.05 | 449.89 | 562.03 | 32.70 |
| 1972/73 | 1,844.93 | 1,162.83 | 276.84 | 28.94 | 90.04 | 194.39 | 574.62 | 32.77 |
| 1973/74 | 2,860.01 | 2,021.24 | 386.58 | 28.40 | 97.05 | 822.87 | 686.34 | 43.32 |
| 1974/75 | 3,420.15 | 2,406.75 | 503.11 | 41.31 | 210.66 | 750.50 | 900.67 | 48.97 |
| 1975/76 | 2,733.49 | 1,622.51 | 487.14 | 59.55 | 199.66 | 701.17 | 774.56 | 47.[illegible]1 |
| 1976/77 | 2,831.41 | 1,660.71 | 467.04 | 55.60 | 200.28 | 219.52 | 718.18 | 49.05 |
| 1977/78 | 2,855.22 | 1,626.34 | 493.00 | 63.94 | 226.02 | 132.85 | 710.50 | 51.98 |
| 1978/79 | 3,399.05 | 2,062.16 | 478.17 | 74.80 | 330.89 | 358.12 | 873.15 | 60.85 |
| 1979/80 | 3,540.38 | 2,154.52 | 490.73 | 68.29 | 284.98 | 678.55 | 931.97 | 68.26 |
| 1980/81 | 3,579.38 | 1,934.82 | 478.11 | 57.04 | 320.23 | 139.91 | 939.53 | 80.35 |
| 1981/82 | 4,588.26 | 2,952.44 | 590.61 | 64.69 | 391.40 | 812.07 | 999.15 | 95.61 |
| 1982/83 | 5,093.02 | 3,223.05 | 604.26 | 80.59 | 405.06 | 865.74 | 1,267.40 | 103.36 |
| 1983/84 | 5,008.08 | 3,059.75 | 628.58 | 77.25 | 444.37 | 555.51 | 1,354.04 | 98.08 |

Source: Based on data from India, Ministry of Agriculture and Cooperation, "Comprehensive Scheme for Studying Cost of Cultivation of Principal Crops in India" (Directorate of Economics and Statistics, Delhi, various years, mimeographed).

Note: n.a. means not available.

[a]Value of output divided by numbers of workers.

## Table 8—Regression results for value of output, factor shares in value added, and labor productivity in wheat cultivation in Punjab, 1970/71-1983/84

| Dependent Variables | Independent Variables | | |
|---|---|---|---|
| | Constant | Time | $R^2$ |
| VA/VO | 0.6817 | −0.00488<br>(2.41)* | 0.327 |
| W/VA | 0.2485 | −0.0039<br>(0.871) | 0.060 |
| (D + I + S)/VA | 0.3281 | −0.00178<br>(0.257) | 0.005 |
| (D + I)/VA | 0.0900 | 0.0236<br>(3.406)* | 0.492 |
| (D + I)/(VA − S) | 0.1208 | 0.0203<br>(5.14)* | 0.687 |
| D/VA | 0.0266 | 0.0015<br>(0.16) | 0.002 |
| R/VA | 0.4096 | −0.0008<br>(0.23) | 0.004 |

Note: Figures in parentheses refer to t-values.

*Significant at 0.05 level.

Definitions of dependent variables:

VA = gross value added;
VO = value of output;
W = wages;
D = depreciation;
I = interest;
S = surplus; and
R = rent.

conclusions can be drawn. First, value added as a proportion of value of output has shown a declining trend that is statistically significant. This tends to confirm that, while the share of intermediate inputs in the value of output has increased, the share of value added has notably declined.

Second, as expected, the share of interest and depreciation in value added has shown an increasing trend, and the result is statistically significant.

Third, no firm conclusions can be drawn concerning the share of wages in value added. Although the regression equation has the expected negative sign, the result is statistically insignificant. Furthermore, with increased labor productivity, a corresponding increase in wage rates over time would have been expected. Nominal wage rates, when regressed on the money value of wheat output per worker (labor productivity) from 1971/72 to 1983/84, give the following equation (figure in parentheses is t-value):

$$\log(\text{wages}) = 55.04 + \underset{(5.98)}{0.51}\,(\text{labor productivity}); \qquad (1)$$

$$R^2 = 0.765.$$

The relationship between the two variables is quite significant and the value of the regression coefficient is 0.51. Accordingly, the growth rate of wages constitutes only 51 percent of the growth rate of labor productivity in the case of wheat.

Finally, there does not seem to be any significant change in the share of rent in value added. In fact, the regression coefficient has a negative sign and the value is highly insignificant.

## Sharing the Gains of the Green Revolution

The above results are important in explaining the emerging changes in factor shares along with changes in the structure of production, but these do not indicate the distribution of gains of new technology among various categories of cultivators and landless labor. Unfortunately, no up-to-date secondary data or studies exist on income distribution among various sections of the peasantry in Punjab.

As far back as 1975/76, an empirical study was conducted on the impact of the green revolution on income generation and income distribution and on the standard of living of various categories of cultivator households (Bhalla and Chadha 1983). Another study on the income levels of landless labor households refers to the same year (Singh 1986). Based on these studies, some broad generalizations can be made on income distribution in Punjab.

It is generally agreed that a higher growth rate in agriculture tends to reduce rural poverty. The available data show that the state of Punjab, which has had a high agricultural growth rate over a long period, has the lowest poverty ratio among the major states of India (Table 9). The gains from the new technology seem to have trickled down to all sections of the rural population. However, since these gains are distributed more or less in proportion to the initial landholding position, and the landholding distribution is very skewed, the distribution of gains has been quite inequitable. In terms of production efficiency, the marginal and small farmers in the state, despite their limited land base, have a total crop output and farm business income per unit of area that is almost as large as those of the larger farmers. This is because their technological level is nearly as good and they make optimum use of surplus family labor. They are also able to supplement their earnings with wage and other income from nonagricultural occupations. In spite of this, many of them are still living below the poverty line. Although there is evidence to suggest that landless labor has also shared somewhat in

**Table 9—Rural poverty ratio in major Indian states, 1970/71, 1977/78, and 1983/84**

| State | 1970/71[a] | 1977/78 | 1983/84 |
|---|---|---|---|
| Andhra Pradesh | 41.00 | 45.45 | 38.67 |
| Bihar | 59.00 | 57.82 | 51.35 |
| Gujarat | 43.80 | 43.10 | 27.62 |
| Haryana | [b] | 23.21 | 15.19 |
| Karnataka | 47.20 | 53.15 | 37.49 |
| Kerala | 62.00 | 47.37 | 26.05 |
| Madhya Pradesh | 52.90 | 61.63 | 50.30 |
| Maharashtra | 46.60 | 60.36 | 41.50 |
| Orissa | 65.00 | 67.89 | 44.76 |
| Punjab | 23.60[c] | 13.21 | 10.87 |
| Rajasthan | 41.80 | 33.48 | 36.63 |
| Tamil Nadu | 57.30 | 56.26 | 44.08 |
| Uttar Pradesh | 40.60 | 49.79 | 46.48 |
| West Bengal | 70.10 | 58.31 | 43.84 |
| All India | 49.10 | 51.20 | 40.40 |

Sources: For 1970/71, Montek S. Ahluwalia, "Rural Poverty and Agricultural Performance in India," *Journal of Development Studies* 14 (3): 298-323; for 1977/78, India, Ministry of Planning, National Sample Survey Organization, *Sarvekshana*, vol. 9, no. 3 (Delhi: Controller of Publications, 1986); and for 1983/84, India Ministry of Planning, National Sample Survey Organization, *Sarvekshana*, vol. 9, no. 4 (Delhi: Controller of Publications, 1986).

[a] The 1970/71 figures are not strictly comparable with those for 1977/78 and 1983/84 because of differences in the norms used for computing poverty ratios.

[b] Included in Punjab.

[c] Includes Haryana and parts of Himachal Pradesh.

the benefits of the green revolution by obtaining higher wages from agriculture and from expanded nonagricultural occupations, many of these laborers, like the marginal and small farmers, have been unable to rise above the poverty line.

It can therefore be stated that rapid agricultural growth over a long period has made a significant dent in poverty in Punjab. However, because of the limited resource base, the gains of the small and marginal farmers and agricultural laborers have been relatively small, and many from these groups continue to hover around the poverty line. The green revolution in Punjab, as elsewhere in the country, has provided a breathing space by increasing the output and income of all sections of the peasantry and by productively absorbing the increasing labor force into agriculture. But the dynamic of the situation is such that not all increases in the rural labor force can be usefully absorbed into agriculture for all time to come. The primary focus of policymakers should be on the creation of large-scale productive employment in the manufacturing and other nonagricultural sectors through well-planned investment for diversification of the economy.

## Growth of Manufacturing

Because of the very rapid growth of agriculture in Punjab, the state is universally acknowledged as the symbol of the green revolution and the most progressive agricultural state of India. However, what is often forgotten is that the growth of the manufacturing sector has always been perceptibly higher than that of agriculture. During 1960/61-1983/84, income from registered manufacturing in Punjab grew at an annual rate of 7.8 percent, while that from unregistered manufacturing increased at a rate of 6.7

percent. During this period the growth rate of income from manufacturing in India as a whole was only 4.3 percent. Because of its significantly higher growth, Punjab can no longer be considered relatively backward in industrialization. In 1961, with per capita value added in the factory sector amounting to only Rs 4, the state ranked lowest in the level of industrialization among the 14 major states of India. By 1981, per capita value added in the factory sector had increased to Rs 136 (at current prices), and the state ranked seventh in industrialization. By 1985/86, Punjab had further improved its position to fifth place (India, Ministry of Planning, various years [c]).

The nature and composition of manufacturing has undergone a notable change, especially since the advent of the green revolution in the mid-1960s. The 1960s witnessed a phase of rapid agro-industrialization, and the output of small units manufacturing agricultural tools and implements showed particularly fast growth in response to mounting demand from rapidly growing agriculture. In addition, the increase in rural income led to much higher demand for consumption goods. Consequently, many small-scale consumer goods industries came into being. The agro-industries manufacturing agricultural implements and machine tools, fertilizers, pipes and fittings, and automobile parts, and the processing industries such as cotton textiles, sugar, wheat flour, and rice-shelling grew continuously over the 1960/61-1983/84 period. Village industries such as the processing of cereals and pulses, *gur* (brown sugar), and *khandsari* (coarse sugar); oil extraction; pottery; soap; lime; fiber and leather; carpentry; and blacksmithing also showed varying degrees of growth. Another area of rapid development was repair and maintenance activities.

Over time these small-scale units developed into medium- and large-scale units in many instances. With the establishment of some new large industries such as fertilizers, electronics, and tractors in the public sector, and the expansion of the private sector in textiles and hosiery because of export demand, many consumer goods industries in the registered sector also started to grow rapidly.

Within the manufacturing sector, detailed data on output and employment are available for the registered industries only. (Under the Indian Factories Act of 1948, a registered industry is defined as any premises or precincts thereof where 10 or more workers work with the aid of power or where 20 or more workers work without power.) Table 10 gives data on the levels and growth of output and employment in selected industries of Punjab. The data on output provided by the state Economic and Statistical Organization has been deflated at constant 1970/71 prices by using appropriate indexes of prices. It is clear from the table that cotton textiles, the largest industry in the state, recorded a very high rate of growth in both output and employment during 1970/71-1982/83. Apart from catering to domestic demand from Punjab and other states, textiles in general, and hosiery goods in particular, have found a profitable export market, especially in the Soviet Union.

Besides textiles, many durable consumer goods industries such as bicycles, sewing machines, and television sets, and agro-input industries such as fertilizers, agricultural implements, and hand tools have shown remarkable growth in output and employment. The respective growth rates of employment and production given in Table 10 show that the employment elasticity with respect to output is quite high for a wide range of industries, particularly for cotton textiles, steel re-rolling, and automobile parts.

To a large extent, rapid growth and gradual modernization in manufacturing (as in agriculture) have been made possible by rapid development of the power sector, which showed a growth rate of 9.1 percent a year in net value added during 1967/68-1983/84. As noted earlier, from the beginning of planning in 1950/51, Punjab has given very

### Table 10—Levels and growth of production and employment in selected industries in Punjab, 1970/71-1982/83

| Industry | 1970/71 |  | 1973/74 |  | 1976/77 |  | 1979/80 |  | 1980/81 |  | 1982/83 |  | Growth Rates, 1970/71-1982/83 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Production | Employment | Production | Employment | Production | Employment | Production | Employment | Production | Employment | Production | Employment | Production | Employment |
|  | (Rs million) | (persons) | (Rs million) | (persons) | (Rs million) | (persons) | (Rs million) | (persons) | (Rs million) | (persons) | (Rs million) | (persons) | (percent) |  |
| Textiles (cotton) | 216 | 10,174 | 274 | 12,278 | 350 | 16,395 | 742 | 42,698 | 857 | 47,726 | 1,028 | 65,410 | 16.19 | 19.14 |
| Textiles (silk, woolen, synthetic, and hosiery) | 517 | 66,203 | 674 | 81,817 | 765 | 73,923 | 1,126 | 87,643 | 1,067 | 91,792 | 987 | 86,710 | 6.95 | 2.49 |
| Cotton ginning and pressing | 206 | 6,310 | 454 | 6,223 | 561 | 7,418 | 531 | 8,168 | 505 | 8,425 | 574 | 8,910 | 9.42 | 3.66 |
| Sugar | 79 | 4,645 | 71 | 4,653 | 96 | 5,073 | 78 | 5,052 | 78 | 5,178 | 220 | 6,210 | 8.82 | 3.23 |
| Bicycles and parts | 172 | 14,620 | 445 | 30,921 | 461 | 34,749 | 739 | 40,114 | 924 | 42,081 | 1,442 | 61,010 | 15.96 | 10.07 |
| Sewing machines | 40 | 6,907 | 48 | 7,614 | 69 | 8,187 | 60 | 8,496 | 64 | 8,735 | 105 | 12,102 | 7.92 | 4.23 |
| Agricultural implements | 216 | 25,535 | 20[illegible] | 26,813 | 313 | 24,258 | 389 | 31,334 | 423 | 34,375 | 704 | 48,401 | 10.23 | 4.53 |
| Hand tools | 20 | 1,577 | 42 | 2,701 | 47 | 3,035 | 82 | 5,636 | 105 | 6,608 | 149 | 9,370 | 15.38 | 13.74 |
| Steel re-rollings | 215 | 4,886 | 430 | 9,525 | 444 | 12,778 | 469 | 10,480 | 491 | 10,604 | 405 | 11,260 | 5.86 | 5.71 |
| Water-pipe fittings | 67 | 5,908 | 69 | 7,595 | 77 | 6,768 | 92 | 9,669 | 92 | 9,905 | 120 | 12,690 | 5.76 | 6.11 |
| Nuts and bolts | 21 | 2,411 | 38 | 3,056 | 53 | 4,758 | 93 | 6,924 | 96 | 7,454 | 113 | 8,690 | 16.71 | 12.25 |
| Scientific and surgical instruments | 8 | 2,398 | 11 | 2,948 | 10 | 1,304 | 9 | 2,040 | 15 | 2,675 | 23 | 2,860 | 4.38 | -1.05 |
| Fertilizers | 115 | 3,413 | 202 | 3,964 | 159 | 3,775 | 524 | 4,810 | 495 | 4,899 | 1,023 | 5,310 | 18.73 | 3.53 |
| Automobile parts | 156 | 8,049 | 175 | 9,511 | 216 | 10,908 | 169 | 13,174 | 158 | 14,335 | 194 | 17,705 | 1.79 | 6.66 |

Sources: Based on data from Punjab, *The Statistical Abstract of Punjab*, various issues (Chandigarh: Economic and Statistical Adviser, various years). Output figures in current prices have been deflated to constant 1970/71 prices by using all-India price deflators from national account data in India, Ministry of Planning, Central Statistical Organization, *National Accounts Statistics*, various issues (Delhi: Controller of Publications, various years).

high priority to investment in power. From two-thirds to three-fourths of the total plan outlay in all the plan periods has gone to power and irrigation.

The estimates of net value added in construction have been thoroughly revised for all the years after 1970/71 by the state Economic and Statistical Organization[6] The annual growth rate of net value added by construction was about 5.0 percent during 1970/71-1983/84.

It can be legitimately argued that given the high growth of agriculture in Punjab, the growth of manufacturing in the state has fallen considerably short of expected levels. To some extent the growth rate may appear understated when calculated for value added and not value of output. An annual growth rate of about 7 percent for value added in manufacturing (as in Table 1) may imply a growth rate of about 9-10 percent in value of output. However, even this order of manufacturing growth could not be considered consistent with the agricultural growth recorded in the state.

A few reasons can be advanced for manufacturing growth lagging behind expectations. The first is import leakages. As will be discussed in detail, Punjab's economy is linked with the rest of the country. This has enabled the state to derive a great deal of comparative advantage through specialization, both in certain crops and in some manufacturing lines. However, historically determined regional distribution of manufacturing capacities, particularly in agroprocessing and agro-input industries, often does not conform with present patterns of agricultural output.

Second, because of the extraordinary increase in output in many cases, the existing processing capacities fall far short of requirements. Sufficient investment has not been undertaken to increase processing capacities, particularly in new areas that have recently started to produce substantial marketable surpluses. Both these factors have militated against a rapid rise of manufacturing in the state. In particular, lack of sufficient investment in agroprocessing seems to have acted as a major constraint. For example, as of January 1, 1983, with a 16.2 percent share in the production of raw cotton, Punjab had only 1.7 percent of all installed spindles and 0.6 percent of all looms in India. With 21.4 percent of wheat output and a 62.0 percent share in wheat procured by the Food Corporation of India, the state had merely 5.8 percent of the roller flour mill capacity in the country. With the recent development of a new variety (COJ 64), Punjab has emerged as one of the most efficient producers of sugarcane, but with 3.4 percent of total cane output, the state had only 1.8 percent of the national capacity for cane conversion. Thus lack of investment in agroprocessing seems to be one important reason for the slower-than-expected growth rate of manufacturing.

Other reasons are perhaps sociological. It takes a long time for peasant societies to switch over to the regular rhythm and discipline of industrial culture. Also, the tensions in Punjab during the 1980s have certainly resulted in further reducing industrial investments in the state and in driving away prospective entrepreneurs.

## Changes in the Tertiary Sector

From 1960/61 to 1983/84, while income from the tertiary sector as a whole recorded an annual growth rate of 6.8 percent, that from trade and transport grew at a rate of more than 6.5 percent, banking and insurance at 8.1 percent, and public administration at 8.6 percent. Growth of the tertiary sector is an essential concomitant of a growing economy. For example, the rapid growth of trade and transport is in response to marked increases in marketed agricultural surpluses, much larger activity in agroprocessing and agro-input industries, and increased flow of exports and imports.

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[6] The estimate of net product from construction rose from Rs 440 million in 1969/70 to Rs 960 million in 1970/71. Since these series were not carried back to the 1960s, the growth rates for 1960/61-1983/84 calculated from available data can be misleading.

Of particular interest in this context is the role of small market villages and towns that lie on main roads connecting larger townships. These villages and towns have gradually become hubs of economic activity, not only in trading and agroprocessing and repairs but also in the provision of social services, health, and recreation. In many cases they have emerged as tiny growth centers serving a network of peripheral villages. The rapid growth of trade, hotels and restaurants, and personal services is in response to increased consumption expenditure. Government and private expenditure on education, health, and other services is also rising rapidly. Rapid growth of public administration is primarily due to the growing role of the state in the development process as well as the excessive overstaffing characteristic of developing countries.

# 3

# METHOD OF COMPILATION AND SOURCES OF DATA

The Punjab input-output table for the year 1969/70, which was published in a study on Punjab, Haryana, and Gujarat (Alagh, Bhalla, and Kashyap 1980), contains an elaborate account of the method of compilation of the interindustry table and the sources of data, including the sectorization scheme, the limitations of the data, and the various improvisations made by the authors. In view of this, instead of giving full details, only a brief description of the methodology used to compile the 1979/80 input-output table (Appendix 1, Table 44) and its sources of data is contained in the present report.

## Compilation of Input-Output Table

The first step in the preparation of the 1979/80 input-output table was the sectorization of the economic activities in Punjab, with the main aim of having as detailed and meaningful a picture of the economy as possible within the framework of available data. In this table the state economy is divided into 39 sectors, compared with 36 sectors in the 1969/70 table. A description of the sector scheme of the 1979/80 table, along with a comparative sector scheme used in 1969/70, is given in Table 11. A detailed description of activities included in each sector is provided in Appendix 2.

Several features of the sector scheme are worth noting. First, since agriculture constitutes a major part of the economy, it has been subdivided into seven sectors containing the main crops in the state. The 1969/70 table had nine sectors for agriculture. However, since *bajra* (pearl millet) and maize have ceased to be important crops in the state, they have been combined with other agriculture and forestry in the 1979/80 table.

Second, in the 1969/70 table, separate vectors were constructed for the ordinary and improved varieties of wheat, rice, cotton, and maize, but that has not been done in the 1979/80 table, primarily because by 1979/80 almost the entire area under wheat, rice, and cotton had been brought under improved varieties.

Third, an important feature of the 1979/80 table is that trade, transport and storage, services, banking and insurance, and ownership of dwellings, which were put below the line in the earlier table, are treated as independent sectors in the structural matrix. This was done because these sectors have assumed considerable importance with the growth of the economy.

Fourth, another important feature of the 1979/80 table is that, compared with 1969/70, much better estimates have been made of exports and imports. Although the Railways Board regularly publishes data on interstate movement of commodities by rail (India, Ministry of Railways), data on interstate movement of commodities by road became available for the first time for 1978/79 as a result of a special survey conducted by the Railways India Technical and Economic Services (RITES). The unpublished data, obtained from RITES, have been updated for the present study to derive the export and import vectors for 1979/80.

## Table 11—Sectoral classifications of the Punjab economy, 1979/80 and 1969/70

| Sector Number, 1979/80 | Description of Sector in 1979/80 | Sector Number | | Comparative Sector in 1969/70 |
|---|---|---|---|---|
| | | 1969/70 | 1979/80 | |
| 1 | Wheat | 1 | (1) | Wheat |
| 2 | Rice | 2 | (2) | Rice |
| | ... | 3 | ... | Maize |
| 3 | Cotton | 4 | (3) | Cotton |
| 4 | Sugarcane | 5 | (4) | Sugarcane |
| 5 | Gram and pulses | 6 | (5) | Gram and pulses |
| 6 | Oilseeds | 7 | (6) | Oilseeds |
| | ... | 8 | ... | Bajra |
| 7 | Other agriculture and forestry | 9 | (7) | Other agriculture |
| 8 | Animal husbandry | 10 | (8) | Animal husbandry |
| 9 | Dairy products and confectionery | 11 | (9) | Dairy products |
| 10 | Grain mill products | 12 | (10) | Grain mill products |
| 11 | Bakery products | ... | ... | ... |
| 12 | Sugar | 13 | (11, 12) | Sugar and confectionery |
| 13 | Other food industries | ... | ... | ... |
| 14 | Edible oils | 14 | (13, 14) | Edible oils and other foods |
| 15 | Breweries and beverages | 15 | (15) | Breweries and beverages |
| 16 | Ginning and textiles | 16 | (16) | Textiles |
| 17 | Sawmills and wooden goods | 17 | (16) | Cotton ginning, pressing, and other textiles |
| 18 | Paper, printing, and publishing | 18 | (17) | Sawmills and wooden containers |
| 19 | Rubber and leather products | 19 | (17) | Furniture and fixtures |
| | ... | 20 | (18) | Printing and publishing |
| | ... | 21 | (19) | Rubber and leather products |
| 20 | Basic chemicals, including fertilizers | 22 | (20) | Basic chemicals, including fertilizers |
| 21 | Drugs and pharmaceuticals | ... | ... | ... |
| 22 | Other chemicals | ... | ... | ... |
| | ... | 23 | (21, 22) | Other chemicals |
| 23 | Glass and mineral products | 24 | (23) | Glass and mineral products |
| 24 | Basic metal industries | 25 | (24) | Basic metal industries |
| 25 | Metal products | 26 | (25) | Metal products |
| 26 | Machinery, except electrical | 27 | (26) | Machinery, except electrical |
| 27 | Electrical machinery | 28 | (27) | Electrical machinery |
| 28 | Railroad equipment | 29 | (28) | Railroad equipment |
| 29 | Motor vehicles, manufacture and repair | ... | ... | ... |
| | ... | 30 | (29) | Transport equipment |
| | ... | 31 | (29) | Repair of transport equipment |
| 30 | Bicycles and parts | 32 | (30) | Motorcycles and bicycles |
| 31 | Scientific and surgical instruments | 33 | (31) | Scientific and surgical instruments |
| 32 | Sports and athletic goods | ... | ... | ... |
| 33 | Miscellaneous industries | ... | ... | ... |
| | ... | 34 | (32, 33) | Miscellaneous industries |
| 34 | Electricity, gas, and water supply | 34 | (36) | Electricity |
| 35 | Construction | 35 | (35) | Construction |
| 36 | Trade, transport, and storage | ... | ... | ... |
| 37 | Other services | ... | ... | ... |
| 38 | Banking and insurance | ... | ... | ... |
| 39 | Real estate and ownership of dwellings | ... | ... | ... |

Source: Based on extract from "National Industrial Classification—1970," reproduced in India, Ministry of Planning, Central Statistical Organization, *Annual Survey of Industries, 1980-81* (Delhi: Controller of Publications, 1983).

Fifth, as in the 1969/70 table, in order to impart greater stability to input coefficients, the flow entries for 1979/80 have been calculated at producers' prices. In the absence of detailed data at the state level, most of the "trade and transport margins" used to convert purchasers' prices into producers' prices were obtained from the 1979/80 input-output table for India (India, Planning Commission 1981). For some important sectors such as agriculture, these prices have been derived from the annual reports of the Food Corporation of India and other secondary sources. Table 12 gives producers' and purchasers' prices and trade and transport margins for various sectors. The use of all-India trade margins for Punjab assumes that the trade margins prevailing in different sectors in the state are similar to those prevailing in India as a whole—an assumption that has undoubtedly introduced some errors into the estimates.

**Table 12—Sectoral trade margins: purchasers'-producers' price ratios, 1979/80**

| Sector Number | Sector | Price Ratio | |
|---|---|---|---|
| | | Wholesale[a] | Retail Trade[b] |
| 1 | Wheat | 1.0712 | 1.0981 |
| 2 | Rice | 1.0595 | 1.1138 |
| 3 | Cotton | 1.0451 | n.a.[c] |
| 4 | Sugarcane | 1.0718 | n.a.[c] |
| 5 | Gram and pulses | 1.1016 | 1.2132 |
| 6 | Oilseeds | 1.0645 | n.a.[c] |
| 7 | Other agriculture and forestry | 1.0645 | n.a.[c] |
| 8 | Animal husbandry | 1.0557 | 1.0889 |
| 9 | Dairy products and confectionery | 1.1314 | 1.1420 |
| 10 | Grain mill products | 1.0775 | 1.2000 |
| 11 | Bakery products | 1.1314 | n.a.[c] |
| 12 | Sugar | 1.0823 | 1.2980 |
| 13 | Other food industries | 1.0131 | 1.3600 |
| 14 | Edible oils | 1.1068 | 1.1600 |
| 15 | Breweries and beverages | 1.0764 | 1.2400 |
| 16 | Ginning and textiles | 1.0732 | 1.2300 |
| 17 | Sawmills and wooden goods | 1.1118 | 1.2800 |
| 18 | Paper, printing, and publishing | 1.1344 | 1.1900 |
| 19 | Rubber and leather products | 1.1065 | 1.2200 |
| 20 | Basic chemicals, including fertilizers | 1.0984 | n.a.[c] |
| 21 | Drugs and pharmaceuticals | 1.1103 | 1.3000 |
| 22 | Other chemicals | 1.0784 | 1.1700 |
| 23 | Glass and mineral products | 1.1518 | 1.3300 |
| 24 | Basic metal industries | 1.1556 | 1.3300 |
| 25 | Metal products | 1.1091 | n.a.[c] |
| 26 | Machinery, except electrical | 1.1153 | n.a.[c] |
| 27 | Electrical machinery | 1.0996 | 1.4700 |
| 28 | Railroad equipment | 1.1246 | n.a.[c] |
| 29 | Motor vehicles, manufacture and repairs | 1.1051 | 1.2700 |
| 30 | Bicycles and parts | 1.1315 | n.a.[c] |
| 31 | Scientific and surgical instruments | 1.1401 | n.a.[c] |
| 32 | Sports and athletic goods | 1.1401 | n.a.[c] |
| 33 | Miscellaneous industries | . . . | 1.3500 |

Sources: Based on data from India, Planning Commission, *A Technical Note on the Sixth Plan of India: 1980-85* (Delhi: Controller of Publications, 1981); and India, Food Corporation of India, *Annual Report*, various issues (Delhi: FCI, various years).

Note: n.a. means not available.

[a] These ratios have been used to arrive at trade and transport margins for all the sectors.

[b] These ratios have been used to arrive at trade and transport margins for the consumption sectors.

[c] The retail price indexes for these commodities are not constricted.

## Sources of Data

Like the 1969/70 input-output table, the 1979/80 table has been compiled mainly on the basis of secondary data. The only source of primary data was a survey of unregistered urban industries conducted by the authors during this study to derive input-output coefficients for the unregistered small-scale units and for some unorganized activities in the tertiary sector. Most of the data for both the 1969/70 and 1979/80 tables were obtained from the Economic and Statistical Organization of the Government of Punjab, particularly from the state income section of this organization. The data provided by this organization have been supplemented from numerous other secondary sources. A brief description of the sources of data is given below by sector.

### Agricultural Sectors

In the 1979/80 input-output table (Appendix 1, Table 44), agriculture is broken into seven sectors: wheat, rice, cotton, sugarcane, gram and pulses, oilseeds, and other agriculture and forestry. Detailed input vectors by crop have been prepared by using the data obtained from the Comprehensive Scheme on Cost of Cultivation of Principal Crops for Punjab compiled by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Some of these data are published in reports of the Agricultural Prices Commission. After input coefficients for these crops were obtained, all the inputs were inflated by the estimates of outputs by crop (Punjab, Economic and Statistical Adviser, various years). The input figures by crop for major items such as cost of fertilizers, electricity charges, and cost of bullocks and implements were then aggregated and adjusted by using as control figures the data on total inputs supplied by the Economic and Statistical Adviser. Figures for value added for each included crop were similarly kept within the control figures.

### Animal Husbandry

The basic information on levels of output, value added, and input costs for animal husbandry was obtained from the Punjab Economic and Statistical Adviser. Two major changes have been made for 1979/80 in calculating value added in this sector. First, unlike the method followed in the state income estimates, bullocks have been treated as a part of the animal husbandry sector and not the agricultural sectors. Second, both depreciation of bullocks and the changes in their stock have been shown in the animal husbandry sector. Depreciation of bullocks has been estimated from the data on comprehensive cost of cultivation, while data on changes in their stock were obtained from the recent publications of the government (Punjab, Economic and Statistical Organization 1980b, 1980c, 1980d).

### Industrial Sectors

Of the 39 sectors in the 1979/80 Punjab input-output table, 24 pertain to industries and public utilities. In India, the registered factories are covered under the Factories Act of 1948 and are required to submit detailed returns to the government containing, among other things, information on output, inputs, value added, workers, and wages. The data for both the census and the sample sectors are published, with some time lag, in the Annual Survey of Industries. For the registered factories in Punjab, the relevant data for 1979/80 were obtained from the Economic and Statistical Adviser. These have since been published (India, Ministry of Planning 1989).

### Unregistered Industrial Sectors

The state income section of the Punjab Economic and Statistical Organization prepares the value of output and value added estimates for the unorganized industries, classified according to the National Industrial Classification. Since these estimates refer only to value added and output, they cannot be used to prepare the input vectors for the unregistered industries.

With the basic aim of obtaining input vectors for the unregistered industries, a survey of 803 industrial units in 10 urban centers in Punjab was conducted by the authors during 1982/83. The results obtained from this survey have been used to arrive at the input structure for most of the industries in the unregistered sector. The separate input-output vectors prepared for the registered and unregistered industries have been combined in the 1979/80 input-output table.

An important additional source of information on rural and urban household industries was the 29th round (July 1974-June 1975) of the National Sample Survey Organization on Survey of Self-Employment in Nonagricultural Enterprises (India, Ministry of Planning 1978). Although this survey does not give details of the input structure of various household industries, it does contain useful information on the estimated number of workers wholly or partly employed in household industries, including value added and wages per worker. Nevertheless, the unavailability of reliable data on the input structure of the unregistered and household industries is a serious limitation on the industrial statistics for Punjab.

### Electricity and Water Supply

Data on total output, value added, number of workers, and input structure were obtained by analyzing the Statement of Accounts for 1979/80 and the Administration Report for 1979/80 of the Punjab State Electricity Board (Punjab, Electricity Board 1980). It has been assumed that the Punjab share of hydroelectric power from Bhakra Dam is being produced within the state. Due to the unavailability of data, it was not possible to include the input vector for the water-supply undertakings in Punjab.

### Other Sectors

The Punjab Economic and Statistical Organization provides separate data on value added in construction, trade, transport and storage, other services, banking and insurance, real estate and ownership of dwellings (Punjab, Economic and Statistical Adviser, various years). However, no details are available regarding their input structure. In the 1979/80 Punjab input-output table, the input structure for each of these sectors has been borrowed from the all-India input-output table for 1979/80 (India, Planning Commission 1981).

## Final Demand

### Household Consumption

The National Sample Survey Organization (NSSO) collects information on consumer expenditure through its various rounds. The expenditure estimates are given separately for the rural and urban population of all the states for 21 aggregate commodity groups and are also available at a disaggregated level for 321 commodities. The latest information available to the authors on consumption expenditure in Punjab pertains to calendar year 1983. This was available from the 38th round of the National Sample Survey (India, Ministry of Planning 1986b). Similar information for 1977/78 was available from the 32nd round (India, Ministry of Planning 1986a).

The task of the present study was to derive the per capita consumption expenditure and its composition for the year 1979/80. The per capita consumption figures for 1977/78 given in the 32nd round of the National Sample Survey have been extrapolated to estimate the per capita expenditure for 1979/80, while the 38th round data have been used to derive the share of consumption expenditure by commodity for 1979/80.

Several steps were involved and several adjustments became necessary to derive per capita consumption expenditure for 1979/80 from the 1977/78 estimates. The first step was to multiply the 1977/78 per capita estimated consumption expenditure of Rs 1,372.68 per month in rural households and Rs 1,256.48 per month in urban households by the 1979/80 rural and urban population estimated by the authors. A total estimated consumption expenditure amounting to more than Rs 22.7 billion was obtained for 1979/80 at per capita income levels and prices of 1977/78.

The second adjustment was made to take into account the increase in consumption as a result of the increase in real per capita income since 1977/78. At constant 1970/71 prices, between 1970/71 and 1983/84 real per capita income rose at an annual rate of 3.2 percent. Thus, assuming the income elasticity of consumption to be 0.7, total consumption for 1979/80 increased by 4.6 percent. After this adjustment, total consumption is nearly Rs 23.8 billion.

The above consumption estimates for 1979/80 were at 1977/78 prices. During 1977/78-1979/80, the consumer price index for agricultural labor rose by 12 percent and that for nonmanual employees by 11.48 percent. Inflating the 1977/78 estimates by 12 percent, an estimate of more than Rs 26.6 billion was obtained for total consumption in the state during 1979/80 at current prices.

The last adjustment was made by comparing the National Sample Survey consumption estimates with those of the Central Statistical Organization (CSO), Government of India. At the all-India level, the consumption estimates by the CSO were considerably higher than the consumption figures estimated by the NSSO. Thus, total 1977/78 consumption as estimated by the CSO was 10.2 percent higher than that estimated by the NSSO. In 1983/84 the NSSO estimates fell short of the CSO estimates by as much as 23.5 percent. Keeping in mind the gross underestimation of consumption by the NSSO, the authors inflated their figure by about 10.0 percent (9.0 percent for rural and 11.7 percent for urban households) and estimated the total consumption in Punjab during 1979/80 at about Rs 29.2 billion. This consumption level gives an average propensity to consume of 63.4 percent in relation to GDP. In the 1969/70 input-output table the estimated average propensity to consume was about 61.1 percent.

The above adjustments were necessary because of the absence of direct estimates of consumption by the Punjab Economic and Statistical Organization. The limitations of the authors' consumption estimates should be kept in mind.

### Government Consumption

The main source of statistics on the state government's current and capital expenditure is the Economic and Functional Classification of the Punjab Government Budget for 1979/80 (Punjab, Economic and Statistical Organization 1980a). That publication, however, does not contain a breakdown of expenditure on commodities according to the sector classification used in this study. For 1969/70, the information on the input structure of the government sector was obtained from the Controller of Stores, Government of Punjab. In the 1979/80 input-output table, distribution of current expenditure has been done according to the 1969/70 table. In addition, the details about current and capital expenditures of the municipalities and local bodies were obtained from the Economic and Functional Classification of the Municipal Budget in Punjab for 1980/81

(Punjab, Economic and Statistical Organization 1981). Since the value added in the government sector, amounting to more than Rs 2 billion, has been included in the service sector, this figure is not shown separately under government consumption.

### Gross Fixed Capital Formation

The available information on gross fixed capital formation is not very comprehensive. For the registered industries, detailed data on investment, along with their breakdown into construction and machinery, are regularly collected through the Annual Survey of Industries conducted by the CSO in the Ministry of Planning. No regular data are available on gross fixed capital formation in the unregistered industrial sectors or in the agriculture, animal husbandry, or service sectors.

In 1980, for the first time, the Government of Punjab brought out three important publications on capital formation in rural households, in urban households, and by state government and local authorities (Punjab, Economic and Statistical Organization 1980b, 1980c, 1980d). These publications have helped considerably in filling the data gap and have been extensively used in this study to build estimates on capital formation in the various sectors. For example, data on capital formation in agricultural and nonagricultural enterprises and by state government and public enterprises—broken down into buildings, plants and machinery, tools, transport equipment, tubewells, land reclamation, and so forth—have been taken from these sources.

In addition, the Annual Survey of Industries has been used to obtain data on investment in various registered industries (India, Ministry of Planning 1989). Since no direct information is available on capital formation in the unregistered industrial sector, these data have been estimated from the publications on capital formation (Punjab, Economic and Statistical Organization 1980b, 1980c, 1980d).

The Economic and Statistical Organization gives independent estimates of value added in the construction sector. Whereas the input structure for the construction sector has been estimated by using the ratios in the all-India table for 1979/80 (India, Planning Commission 1981), the entire output in construction has been allocated to "gross fixed capital formation."

### Changes in Stocks

The information on changes in stocks has been collected from several sources. For registered industries, it is available in the Annual Survey of Industries (India, Ministry of Planning 1989). For the government sector and the government administration as well as government departments, this information is available in the Economic and Functional Classification of the Budget (Punjab, Economic and Statistical Organization 1980a), as is information on changes in foodgrain stocks on government account. No ready information is available regarding changes in stocks in the unregistered or household industries or in agriculture. However, very detailed information on changes in stocks of rural and urban households, the state government and local authorities, and departmental enterprises has been obtained from the publications on capital formation (Punjab, Economic and Statistical Organization 1980b, 1980c, 1980d).

### Exports and Imports

Detailed time series information is available on the physical quantities of exports and imports of goods hauled by railways, but no comprehensive time series data are available on the quantities exported and imported into Punjab through road transport. For 1978/79, however, Railways India Technical and Economic Services (RITES), a subsidiary of Indian Railways, conducted a special survey to collect information on exports from and imports into various states of India. For the present study, this information, obtained from RITES, has been updated in order to derive the export and import estimates. In addition, the export and import information for wheat and rice has been obtained from the annual reports of the Food Corporation of India. It should be noted that the export and import data given by Indian Railways and by RITES are in quantities and not in value terms. Various sources have been used to obtain the prices of traded commodities and thereby derive value estimates of exports and imports. For some sectors for which export and import figures are not available from any source, the figures have been derived as residuals.

The imports into Punjab have been divided into two sets, namely, competitive and noncompetitive. All imports of commodities that are not produced within the state have been allocated to noncompetitive imports. The export-import estimates for the Punjab input-output in 1979/80 have considerably improved due to the availability of the RITES data on interstate commodity flow by road, although there is still room for improvement.

## Entries Below the Line

Apart from factor payments, the other entries below the line are noncompetitive imports, repair and maintenance, work done by others, taxes, duties and subsidies, consumable stores, and depreciation. For the agricultural sector, information on these entries has been obtained from the reports of the Comprehensive Scheme of Cost of Cultivation prepared by the Economic and Statistical Adviser, Government of India. For the registered sector, this information has been taken from the Annual Survey of Industries for 1979/80 (India, Ministry of Planning). For the unregistered sector, the estimates for noncompetitive imports, repair and maintenance, and work done by others have been prepared by using a variety of sources. For example, for the 1979/80 input-output table, noncompetitive imports have been estimated as a residual, since there are intermediate inputs and components of final demand that are not being produced in the state. Again, data available for 1975-77 (in the 1982 Statistical Abstract of Punjab) on such items as output and employment in repair services for the unregistered manufacturing industrial units have been projected to derive 1979/80 estimates.

### Wages

The most important entry below the line pertains to net value added and its breakdown into wages and other factor payments. In this study, only the calculation of wages is considered. Separate information on interest, rent, wages, and profits in the agricultural sector is not directly available because, in most cases, the cultivator himself provides all or part of land, capital, and labor in the process of agricultural production. The data collected under the Comprehensive Scheme of Cost of Cultivation (India, Agricultural Prices Commission, various years) have been used to estimate the share of wages in net value added by various agricultural sectors. Information from the Annual Survey of Industries (India, Ministry of Planning), which gives detailed information on factor payments for each industry in the registered sectors, has been used to estimate the wages paid in these sectors.

Wages in the unregistered and service sectors have been obtained from various sources. The National Accounts Statistics (India, Ministry of Planning, various years) provide information on compensation to employees in nine sector classifications. This information has been used to obtain the ratio of wages to net value added in each of these sectors, and thus to derive wages. The Labor Commissioner of Punjab provides information on the average annual earnings of workers in some occupations in the unregistered sectors, and this information, as published in the Statistical Abstract of Punjab (Punjab, Economic and Statistical Adviser, various years) has also been used to calculate wages.

In addition, the results of the 29th round of the National Sample Survey of rural and urban household industries (India, Ministry of Planning 1978) have been used to calculate wages in various household industries. For the 1979/80 input-output table, the wages received in the registered, unregistered, and household industries have been combined to calculate the aggregate wages by sectors included in the table. For public administration and other services, including sanitary services, wages are derived by taking the ratio of employee compensation to value added in this sector, as given in the National Accounts Statistics. Although reliable information has been available for wages in many sectors, for the unregistered and unorganized sectors such as agriculture, forestry, animal husbandry, personal services, real estate and dwellings, trade, transport, and communications, this information is weak.

### Workers

The population census of India for 1981 (India, Ministry of Home Affairs 1982) gives details about workers employed in the agriculture and manufacturing sectors at the three-digit level. This census was the main source for estimating workers by sectors. The information on total workers in agriculture was broken down into various crop sectors by using the data given in the Comprehensive Scheme of Cost of Cultivation.

For animal husbandry, the census information refers to workers engaged in animal husbandry on a full-time basis. In India, animal husbandry continues to be a part-time activity for most cultivating and noncultivating rural households. Instead of the data given by the census, the number of workers in the animal husbandry sector has been estimated on the assumption that value added per worker in this sector equals that in "other agriculture." The data on the number of workers in registered industries has been obtained directly from the Annual Survey of Industries. The census data have been used to obtain estimates of workers engaged in various sectors in the unorganized and household industries.

### Person-hours

In preparing the 1979/80 Punjab input-output table, it is assumed that a worker in the agricultural sector works 261 days a year on average. Data on person-hours are directly available for the registered industrial sectors. For other sectors, days worked during a year have been estimated from various other sources such as the Statistical Abstract of Punjab and the NSSO's survey of rural and urban household industries (29th round).

## 4

# STRUCTURAL FEATURES OF THE PUNJAB ECONOMY

This chapter briefly discusses the structural features of the Punjab economy and changes in them over time by using the input-output tables for 1969/70 (Alagh, Bhalla, and Kashyap 1980) and 1979/80 (Appendix 1, Table 44). These interindustry flow tables for Punjab present a complete production and income account of the included producing sectors along with the details of disposition of sectoral outputs for intermediate use and final demand. These tables can therefore be used to bring out the relative importance of various sectors and of changes in income and output, labor productivity, and components of final demand that occurred between 1969/70 and 1979/80.

## Distribution of Sectoral Income and Output

The data on real net state domestic product (NSDP) by industry of origin for 1969/70 and 1979/80 at constant 1970/71 prices are contained in Table 1. Tables 13 and 14 give comparable data on state income and output and their sectoral distribution for both 1969/70 and 1979/80 at current prices.

It is clear from Tables 13 and 14 that although the combined share of the agriculture and animal husbandry sectors in total NSDP declined from 61.4 percent in 1969/70 to 47.2 percent in 1979/80, these sectors continue to occupy a predominant place in the Punjab economy.[7] That the state is relatively more dependent on the primary sector is obvious, since in India this sector contributed only 37.5 percent of the net national product in 1979/80. Another notable feature is that in 1979/80, with a 47.2 percent share in value added, the contribution of the primary sector to the gross value of output in Punjab was only 33.9 percent, indicating that because of less use of intermediate inputs relative to other sectors, this sector has significantly higher value added per unit of output.

The secondary sector in Punjab, which at current prices accounted for 15.9 percent of NSDP in 1969/70, increased its share to 20.8 percent in 1979/80. During the same period, the manufacturing sector's share in NSDP increased only from 11.4 percent to 13.0 percent. Despite rapid growth, it is clear that Punjab continues to be relatively less industrialized than India as a whole, since the share of manufacturing in the total net national product of India rose from 14.0 in 1969/70 to 15.9 percent in 1979/80.

The tertiary sector, which accounted for only 22.7 percent of Punjab's NSDP in 1969/70, contributed 32.0 percent of NSDP 1979/80. In India during this period the share of the tertiary sector in the total net national product increased from 30.5 percent to 36.9 percent (India, Ministry of Planning, various years[b]).

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[7] The shares given in Tables 13 and 14 are taken from the two input-output tables and are at current prices. These figures are therefore not comparable to those contained in Table 1, where all data are at constant 1970/71 prices.

## Table 13—Sectoral distribution of net value added and gross value of output in Punjab, 1969/70

| Sector Number | Sector | Net Value Added | Distribution of Net Value Added | Share of Agriculture, Manufacturing, and Tertiary Sectors | Gross Value of Output | Distribution of Gross Value of Output | Share of Agriculture, Manufacturing, and Tertiary Sectors |
|---|---|---|---|---|---|---|---|
| | | (Rs million)[a] | (percent) | | (Rs million)[a] | (percent) | |
| 1 | Wheat | 3,199 | 22.49 | 54.97 | 4,114 | 20.45 | 54.02 |
| 2 | Rice | 327 | 2.30 | 5.62 | 442 | 2.20 | 5.81 |
| 3 | Maize | 357 | 2.51 | 6.14 | 476 | 2.37 | 6.25 |
| 4 | Cotton | 169 | 1.19 | 2.90 | 244 | 1.21 | 3.20 |
| 5 | Sugarcane | 312 | 2.19 | 5.37 | 463 | 2.30 | 6.08 |
| 6 | Gram and pulses | 285 | 2.00 | 4.90 | 390 | 1.94 | 5.13 |
| 7 | Oilseeds | 176 | 1.24 | 3.03 | 251 | 1.25 | 3.29 |
| 8 | Bajra | 122 | 0.86 | 2.09 | 163 | 0.81 | 2.13 |
| 9 | Other agriculture and forestry | 871 | 6.12 | 14.98 | 1,073 | 5.33 | 14.09 |
| | Subtotal: agriculture | 5,818 | 40.90 | 100.00 | 7,617 | 37.85 | 100.00 |
| 10 | Animal husbandry | 2,918 | 20.51 | . . . | 3,697 | 18.37 | . . . |
| | Subtotal: primary[b] | 8,736 | 61.41 | . . . | 11,314 | 56.22 | . . . |
| 11 | Dairy products | 12 | 0.08 | 0.71 | 217 | 1.08 | 2.92 |
| 12 | Grain mill products | 56 | 0.39 | 3.41 | 653 | 3.24 | 8.77 |
| 13 | Sugar and confectionery | 13 | 0.09 | 0.80 | 100 | 0.50 | 1.35 |
| 14 | Edible oils and other food-processing industries | 98 | 0.69 | 5.99 | 664 | 3.30 | 8.93 |
| 15 | Breweries and beverages | 4 | 0.03 | 0.25 | 28 | 0.14 | 0.37 |
| 16 | Textiles | 394 | 2.77 | 24.21 | 1,618 | 8.04 | 21.75 |
| 17 | Cotton ginning, pressing, and other textiles | 24 | 0.17 | 1.49 | 508 | 2.53 | 6.84 |
| 18 | Sawmills and wooden containers | 36 | 0.25 | 2.20 | 131 | 0.65 | 1.76 |
| 19 | Furniture and fixtures | 92 | 0.65 | 5.64 | 272 | 1.35 | 3.66 |
| 20 | Printing and publishing | 13 | 0.09 | 0.81 | 36 | 0.18 | 0.48 |
| 21 | Rubber and leather products | 61 | 0.43 | 3.78 | 216 | 1.07 | 2.90 |
| 22 | Basic chemicals, including fertilizers | 93 | 0.65 | 5.69 | 225 | 1.12 | 3.02 |
| 23 | Other chemicals | 26 | 0.18 | 1.58 | 133 | 0.66 | 1.79 |
| 24 | Glass and mineral products | 94 | 0.66 | 5.75 | 348 | 1.73 | 4.68 |
| 25 | Basic metal industries | 49 | 0.34 | 3.00 | 370 | 1.84 | 4.97 |
| 26 | Metal products | 97 | 0.68 | 5.95 | 356 | 1.77 | 4.78 |
| 27 | Machinery, except electrical | 154 | 1.08 | 9.46 | 510 | 2.53 | 6.85 |
| 28 | Electrical machinery | 24 | 0.17 | 1.46 | 120 | 0.60 | 1.62 |
| 29 | Railroad equipment | 19 | 0.13 | 1.17 | 27 | 0.13 | 0.36 |
| 30 | Transport equipment | 38 | 0.27 | 2.31 | 122 | 0.61 | 1.65 |
| 31 | Repair of transport equipment | 6 | 0.04 | 0.40 | 16 | 0.08 | 0.22 |
| 32 | Motorcycles and bicycles | 45 | 0.33 | 2.76 | 180 | 0.89 | 2.42 |
| 33 | Scientific and surgical instruments | 36 | 0.25 | 2.21 | 58 | 0.29 | 0.79 |
| 34 | Miscellaneous industries | 146 | 1.03 | 8.97 | 530 | 2.63 | 7.12 |
| | Subtotal: manufacturing | 1,629 | 11.45 | 100.00 | 7,439 | 31.10 | 100.00 |
| 35 | Construction | 464 | 3.26 | . . . | 1,179 | 5.86 | . . . |
| 36 | Electricity | 166 | 1.17 | . . . | 190 | 0.95 | . . . |
| | Subtotal: secondary | 2,259 | 15.88 | . . . | 8,808 | 37.91 | . . . |
| 37 | Trade, transport and storage | 1,824 | 12.82 | 56.43 | n.a. | n.a. | n.a. |
| 38 | Other services | 987 | 6.94 | 30.59 | n.a. | n.a. | n.a. |
| 39 | Banking and insurance | 156 | 1.10 | 4.82 | n.a. | n.a. | n.a. |
| 40 | Real estate | 263 | 1.85 | 8.16 | n.a. | n.a. | n.a. |
| | Subtotal: tertiary | 3,230 | 22.71 | 100.00 | n.a. | n.a. | n.a. |
| | Total | 14,225 | 100.00 | . . . | n.a. | n.a. | n.a. |

Source: Based on Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

Notes: n.a. means not available. Parts may not add to totals because of rounding.

[a] At current prices.

[b] Because of neglible contributions, fishing and mining and quarrying have not been included in the primary sector.

## Table 14—Sectoral distribution of net value added and gross value of output in Punjab, 1979/80

| Sector Number | Sector | Net Value Added | Distribution of Net Value Added | Share of Agriculture, Manufacturing, and Tertiary Sectors | Gross Value of Output | Distribution of Gross Value of Output | Share of Agriculture, Manufacturing, and Tertiary Sectors |
|---|---|---|---|---|---|---|---|
| | | (Rs million)[a] | (percent) | | (Rs million)[a] | (percent) | |
| 1 | Wheat | 5,421 | 12.79 | 37.65 | 9,735 | 11.06 | 44.63 |
| 2 | Rice | 3,574 | 8.43 | 24.82 | 5,189 | 5.90 | 23.79 |
| 3 | Cotton | 1,573 | 3.71 | 10.93 | 2,196 | 2.50 | 10.07 |
| 4 | Sugarcane | 650 | 1.53 | 4.51 | 813 | 0.92 | 3.73 |
| 5 | Gram and pulses | 365 | 0.86 | 2.53 | 479 | 0.54 | 2.20 |
| 6 | Oilseeds | 367 | 0.87 | 2.55 | 454 | 0.52 | 2.08 |
| 7 | Other agriculture and forestry | 2,448 | 5.78 | 17.01 | 2,944 | 3.35 | 13.50 |
| | Subtotal: agriculture | 14,398 | 33.97 | 100.00 | 21,810 | 24.78 | 100.00 |
| 8 | Animal husbandry | 5,598 | 13.21 | ... | 7,976 | 9.06 | ... |
| | Subtotal: primary | 19,996 | 47.18 | ... | 29,786 | 33.84 | ... |
| 9 | Dairy products and confectionery | 155 | 0.37 | 2.82 | 669 | 0.76 | 2.43 |
| 10 | Grain mill products | 157 | 0.37 | 2.85 | 1,874 | 2.13 | 6.82 |
| 11 | Bakery products | 53 | 0.12 | 0.96 | 156 | 0.18 | 0.57 |
| 12 | Sugar | 34 | 0.08 | 0.62 | 195 | 0.22 | 0.71 |
| 13 | Other food industries | 140 | 0.33 | 2.56 | 512 | 0.58 | 1.86 |
| 14 | Edible oils | 140 | 0.33 | 2.56 | 1,876 | 2.13 | 6.83 |
| 15 | Breweries and beverages | 47 | 0.11 | 0.86 | 285 | 0.32 | 1.04 |
| 16 | Ginning and textiles | 1,251 | 2.95 | 22.78 | 6,932 | 7.88 | 25.22 |
| 17 | Sawmills and wooden goods | 234 | 0.55 | 4.26 | 601 | 0.68 | 2.19 |
| 18 | Paper, printing, and publishing | 51 | 0.12 | 0.92 | 144 | 0.16 | 0.52 |
| 19 | Rubber and leather products | 233 | 0.55 | 4.25 | 890 | 1.01 | 3.24 |
| 20 | Basic chemicals, including fertilizers | 271 | 0.64 | 4.92 | 1,085 | 1.23 | 3.95 |
| 21 | Drugs and pharmaceuticals | 7 | 0.02 | 0.12 | 39 | 0.04 | 0.14 |
| 22 | Other chemicals | 36 | 0.09 | 0.66 | 233 | 0.27 | 0.85 |
| 23 | Glass and mineral products | 561 | 1.32 | 10.21 | 1,488 | 1.69 | 5.42 |
| 24 | Basic metal industries | 392 | 0.93 | 7.14 | 4,328 | 4.92 | 15.75 |
| 25 | Metal products | 280 | 0.66 | 5.09 | 1,377 | 1.57 | 5.01 |
| 26 | Machinery, except electrical | 241 | 0.57 | 4.38 | 1,119 | 1.27 | 4.07 |
| 27 | Electrical machinery | 112 | 0.26 | 2.04 | 536 | 0.61 | 1.95 |
| 28 | Railroad equipment | 28 | 0.07 | 0.51 | 65 | 0.07 | 0.24 |
| 29 | Motor vehicles, manufacture and repair | 399 | 0.94 | 7.26 | 1,073 | 1.22 | 3.90 |
| 30 | Bicycles and parts | 412 | 0.97 | 7.50 | 1,313 | 1.49 | 4.78 |
| 31 | Scientific and surgical instruments | 25 | 0.06 | 0.45 | 86 | 0.10 | 0.31 |
| 32 | Sports and athletic goods | 102 | 0.24 | 1.86 | 412 | 0.47 | 1.50 |
| 33 | Miscellaneous industries | 133 | 0.31 | 2.42 | 193 | 0.22 | 0.70 |
| | Subtotal: manufacturing | 5,494 | 12.96 | 100.00 | 27,481 | 31.23 | 100.00 |
| 34 | Electricity, gas, water supply | 946 | 2.23 | ... | 1,657 | 1.88 | ... |
| 35 | Construction | 2.393 | 5.65 | ... | 6,853 | 7.79 | ... |
| | Subtotal: secondary | 8,833 | 20.84 | ... | 35,991 | 40.90 | ... |
| 36 | Trade, transport, and storage | 8,649 | 20.41 | 63.83 | 13,841 | 15.73 | 62.28 |
| 37 | Other services | 3,494 | 8.24 | 25.78 | 6,511 | 7.40 | 29.29 |
| 38 | Banking and insurance | 877 | 2.07 | 6.47 | 1,064 | 1.21 | 4.79 |
| 39 | Real estate and ownership of dwellings | 530 | 1.25 | 3.92 | 810 | 0.92 | 3.64 |
| | Subtotal: tertiary | 13,550 | 31.97 | 100.00 | 22,225 | 25.26 | 100.00 |
| | Total | 42,379 | 100.00 | ... | 88,002 | 100.00 | ... |

Source: Based on Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Note: Parts may not add to totals because of rounding.
[a] At current prices.
[b] Because of negligible contributions, fishing and mining and quarrying have not been included in the primary sector.

Some significant structural changes can be discerned within the primary, secondary, and tertiary sectors in Punjab during this period. The first important change is the rapid growth in rice and wheat output and the emergence of rice, along with wheat, as one of the two major crops in the state. Whereas the output of wheat increased by 62 percent, from 4.87 million tons in 1969/70 to 7.90 million tons in 1979/80, that of rice increased nearly six times, from 0.54 million tons to 3.04 million tons (see Table 2). Table 13 shows that in 1969/70 wheat accounted for 54.0 percent and rice for only 5.8 percent of the total value of agricultural output. In 1979/80, the contribution of wheat to the total value of agricultural output declined to 44.6 percent, while that of rice increased to 23.8 percent (Table 14). Thus these two crops together accounted for 68.4 percent of the total value of agricultural output in 1979/80. A similar picture emerges from the contribution of these crops to total value added in agriculture. Whereas wheat accounted for 55.0 percent and rice for 5.6 percent of total value added in agriculture in 1969/70, the contribution of wheat declined in 1979/80 to 37.7 percent, but that of rice increased to 24.8 percent. As discussed earlier, the cropping pattern in Punjab has become increasingly dominated by wheat and rice, and in 1979/80 these two crops accounted for about 61.0 percent of total cropped area in the state (Table 2).

Second, because of widespread adoption of the new seed-fertilizer technology, the use of intermediate inputs, in general, and that of modern inputs, in particular, increased markedly in rice and wheat between 1969/70 and 1979/80. For example, while fertilizers accounted for only 4.4 percent of the total value of wheat output in 1969/70, they contributed 14.5 percent of its value in 1979/80. Noncompetitive imports (fuels and lubricants), which constituted only 0.9 percent of the total value of wheat output in 1969/70, accounted for 13.7 percent in 1979/80. In the case of rice, the proportion of fertilizer to total output increased from 5.7 percent in 1969/70 to 12.5 percent in 1979/80, and that of fuels and lubricants increased from 1.2 percent to 8.7 percent. Consequently, during this period value added as a proportion of value of output registered a notable decline in both these crops, falling from 77.7 percent in 1969/70 to 55.7 percent in 1979/80 for wheat and from 74.0 percent to 68.9 percent for rice.

On the other hand, a perceptible decline occurred in animal draft power used in agricultural production. The expenditure on bullocks (animal husbandry sector), which constituted 7.7 percent of the value of wheat output in 1969/70, accounted for only 2.8 percent in 1979/80. For rice, a similar decline took place in the expenditure on bullocks—from 5.5 percent to 1.4 percent of its value of output during this period. The main cause of this decline is the gradual replacement of animal draft power with mechanical energy such as that of tractors. (See the 1969/70 Punjab input-output table in Alagh, Bhalla, Kashyap 1980 and the 1979/80 Punjab input-output table in Appendix 1 of this study [Table 44].)

Although industrial output recorded a large increase during 1969/70-1979/80, few significant changes occurred in the structure and composition of the manufacturing sector in Punjab. Thus the textile industry continued to be the dominant industry in the state, accounting for nearly one-fourth of the total value of manufacturing output and slightly more than one-fifth of value added in this sector in both 1969/70 and 1979/80. The food products industry, including dairy products, grain mill products, sugar, edible oil, bakery, and other foods, which together accounted for 22.3 percent of the total value of manufacturing output in 1969/70, constituted about 20.3 percent in 1979/80. However, basic metal and metal products industries emerged as major industrial sectors. Together they accounted for 20.8 percent of the total value of manufacturing output and 12.2 percent of total value added in 1979/80, compared with a contribution of 9.8 percent to total output and 9.0 percent to total value added in manufacturing in 1969/70. Manufacture and repair of motor vehicles and manufacture of bicycles and parts also acquired more weight, together accounting for 14.8 percent of value added in the manufacturing sector in 1979/80 compared with only 0.6 percent in 1969/70.

Otherwise, the basic industrial structure of Punjab continues to consist of agriculture-based industries such as cotton textiles, grain mill products, food processing, and edible oils; some agro-input industries such as nonelectrical machinery, basic chemicals, and fertilizers; and some consumer durables such as bicycles, sewing machines, and rubber and leather products.

Taking the secondary sector as a whole, the contribution of both construction and electricity to the value added and value of output of the sector increased significantly between 1969/70 and 1979/80. The share of value added in construction[8] increased from 20.6 percent of total value added in the secondary sector in 1969/70 to 27.1 percent in 1979/80, and that of value added in electricity increased from 7.3 percent to 10.7 percent.

Since the value of total output was not estimated for the tertiary sector in 1969/70, it is not possible to delineate the changes in the distribution of value of output for that sector. However, the data on value added in the tertiary sector indicate that this sector recorded an even higher growth than the primary and the secondary sectors and consequently registered a significant increase in its share of total value added—from 22.7 percent in 1969/70 to 32.0 percent in 1979/80. While trade and transport contributed 12.8 percent to NSDP in 1969/70, its contribution increased to 20.4 percent in 1979/80. During the same period, the contribution made by sectors such as banking, insurance, real estate, public administration, and other services also increased at a rapid rate.

## Output and Productivity

Tables 15 and 16 give details by sector on output and value added per worker in Punjab in 1969/70 and 1979/80. There are large intersectoral variations in output per worker, due to different technologies employed and uneven distribution of productively invested capital over the sectors. The differences in partial labor productivity measured this way give an idea of the relative efficiency of the work force in various sectors in 1969/70 and 1979/80. Since value of output and value added figures are in current prices, it is not possible to use these statistics to measure changes from 1969/70 to 1979/80.

It is, however, possible to get an idea of changes in labor productivity in real terms in the primary and the secondary sectors by using the data on state income in Table 1. During 1969/70-1979/80, per worker value added in real terms increased in both the primary and the secondary sectors. Thus, in constant prices, value added per worker increased from Rs 3,615 in 1969/70 to Rs 4,417 in 1979/80 in the primary sector and from Rs 3,634 to Rs 4,282 in the secondary sector.

Regarding intersectoral differences in labor productivity (at current prices), as shown in Tables 15 and 16, labor productivity was substantially higher in the manufacturing

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[8] As noted earlier, the results for construction should be treated with caution because sectoral income estimates were thoroughly revised in 1970/71 and net value added in construction, which was only Rs 440 million in 1969/70, was raised to Rs 960 million in 1970/71.

### Table 15—Sectoral distribution of workers and of output and value added per worker in Punjab, 1969/70

| Sector Number | Sector | Workers | Distribution | Output per Worker | Value Added per Worker |
|---|---|---|---|---|---|
| | | (persons) | (percent) | (Rs) | |
| 1 | Wheat | 601,142 | 20.61 | 6,844 | 5,322 |
| 2 | Rice | 59,514 | 2.04 | 7,431 | 5,495 |
| 3 | Maize | 101,660 | 3.49 | 4,683 | 3,512 |
| 4 | Cotton | 139,318 | 4.78 | 1,752 | 1,213 |
| 5 | Sugarcane | 146,672 | 5.03 | 3,159 | 2,127 |
| 6 | Gram and pulses | 70,642 | 2.42 | 5,527 | 4,034 |
| 7 | Oilseeds | 72,520 | 2.49 | 3,456 | 2,427 |
| 8 | Bajra | 46,137 | 1.58 | 3,525 | 2,644 |
| 9 | Other agriculture and forestry | 325,292 | 11.15 | 3,299 | 2,678 |
| | Subtotal: agriculture | 1,526,897 | 53.59 | (4,873) | (3,723) |
| 10 | Animal husbandry | 758,629 | 26.01 | 4,873 | 3,846 |
| | Subtotal: primary | 2,321,526 | 79.60 | (4,873) | (3,763) |
| 11 | Dairy products | 1,403 | 0.05 | 154,984 | 8,553 |
| 12 | Grain mill products | 8,926 | 0.31 | 73,134 | 6,274 |
| 13 | Sugar and confectionery | 4,265 | 0.15 | 23,521 | 3,048 |
| 14 | Edible oils and other food-processing industries | 27,051 | 0.93 | 24,561 | 3,623 |
| 15 | Breweries and beverages | 2,114 | 0.07 | 13,151 | 1,892 |
| 16 | Textiles | 110,657 | 3.79 | 14,622 | 3,561 |
| 17 | Cotton ginning, pressing, and other textiles | 9,674 | 0.33 | 53,597 | 2,481 |
| 18 | Sawmills and wooden containers | 9,967 | 0.34 | 13,158 | 3,612 |
| 19 | Furniture and fixtures | 32,588 | 1.12 | 8,348 | 2,823 |
| 20 | Printing and publishing | 5,659 | 0.19 | 6,356 | 2,297 |
| 21 | Rubber and leather products | 25,781 | 0.88 | 8,360 | 2,405 |
| 22 | Basic chemicals, including fertilizers | 2,938 | 0.10 | 76,586 | 31,654 |
| 23 | Other chemicals | 3,838 | 0.13 | 34,628 | 6,774 |
| 24 | Glass and mineral products | 42,657 | 1.46 | 8,161 | 2,204 |
| 25 | Basic metal industries | 10,544 | 0.36 | 35,068 | 2,152 |
| 26 | Metal products | 31,599 | 1.08 | 11,255 | 3,070 |
| 27 | Machinery, except electrical | 33,396 | 1.15 | 15,266 | 4,611 |
| 28 | Electrical machinery | 4,489 | 0.15 | 26,809 | 5,346 |
| 29 | Railroad equipment | 2,853 | 0.10 | 9,367 | 6,660 |
| 30 | Transport equipment | 6,137 | 0.21 | 19,936 | 6,192 |
| 31 | Repair of transport equipment | 2,197 | 0.08 | 7,354 | 3,186 |
| 32 | Motorcycles and bicycles | 7,354 | 0.25 | 24,388 | 6,119 |
| 33 | Scientific and surgical instruments | 7,574 | 0.26 | 7,721 | 4,753 |
| 34 | Miscellaneous industries | 48,470 | 1.66 | 10,936 | 3,076 |
| | Subtotal: manufacturing | 442,131 | 15.16 | (16,825) | (3,684) |
| 35 | Construction | 142,335 | 4.88 | 8,285 | 3,260 |
| 36 | Electricity | 10,243 | 0.35 | 18,590 | 16,206 |
| | Subtotal: secondary | 594,709 | 20.39 | (14,811) | (3,798) |
| | Total (primary and secondary) | 2,916,235 | 100.00 | (6,900) | (3,770) |

Source: Based on Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

Notes: Figures in parentheses are mean values. Parts may not add to totals because of rounding.

## Table 16—Sectoral distribution of workers and of output and value added per worker in Punjab, 1979/80

| Sector Number | Sector | Workers | Distribution | Output per Worker | Value Added per Worker |
|---|---|---|---|---|---|
| | | (persons) | (percent) | (Rs) | |
| 1 | Wheat | 546,440 | 11.80 | 17,814 | 9,921 |
| 2 | Rice | 560,383 | 12.10 | 9,259 | 6,378 |
| 3 | Cotton | 224,272 | 4.84 | 9,792 | 7,014 |
| 4 | Sugarcane | 70,039 | 1.51 | 11,614 | 9,287 |
| 5 | Gram and pulses | 49,703 | 1.07 | 9,629 | 7,344 |
| 6 | Oilseeds | 24,935 | 0.54 | 18,211 | 14,718 |
| 7 | Other agriculture and forestry | 305,759 | 6.60 | 9,629 | 6,306 |
| | Subtotal: agriculture | 1,781,531 | 38.47 | (12,242) | (8,082) |
| 8 | Animal husbandry | 828,295 | 17.89 | 9,629 | 6,758 |
| | Subtotal: primary | 2,609,826 | 56.36 | (11,413) | (7,662) |
| 9 | Dairy products and confectionery | 5,204 | 0.11 | 128,559 | 29,785 |
| 10 | Grain mill products | 23,913 | 0.52 | 78,367 | 6,565 |
| 11 | Bakery products | 11,337 | 0.24 | 13,732 | 4,675 |
| 12 | Sugar | 4,559 | 0.10 | 42,802 | 7,458 |
| 13 | Other food industries | 16,979 | 0.37 | 30,145 | 8,245 |
| 14 | Edible oils | 13,939 | 0.30 | 134,583 | 10,043 |
| 15 | Breweries and beverages | 2,493 | 0.05 | 114,214 | 18,853 |
| 16 | Ginning and textiles | 169,678 | 3.66 | 40,854 | 7,373 |
| 17 | Sawmills and wooden goods | 45,710 | 0.99 | 13,151 | 5,119 |
| 18 | Paper, printing, and publishing | 10,954 | 0.24 | 13,113 | 4,656 |
| 19 | Rubber and leather products | 38,397 | 0.83 | 23,185 | 6,068 |
| 20 | Basic chemicals, including fertilizers | 4,974 | 0.11 | 281,054 | 54,483 |
| 21 | Drugs and pharmaceuticals | 1,020 | 0.02 | 37,899 | 6,863 |
| 22 | Other chemicals | 4,874 | 0.11 | 47,903 | 7,386 |
| 23 | Glass and mineral products | 42,954 | 0.93 | 34,650 | 13,060 |
| 24 | Basic metal industries | 37,271 | 0.80 | 116,129 | 10,518 |
| 25 | Metal products | 52,504 | 1.13 | 26,234 | 5,333 |
| 26 | Machinery, except electrical | 26,795 | 0.58 | 41,762 | 8,994 |
| 27 | Electrical machinery | 8,060 | 0.17 | 66,475 | 13,896 |
| 28 | Railroad equipment | 2,379 | 0.05 | 27,412 | 11,770 |
| 29 | Motor vehicles, manufacture and repair | 70,679 | 1.53 | 15,179 | 5,645 |
| 30 | Bicycles and parts | 37,073 | 0.80 | 35,415 | 11,113 |
| 31 | Scientific and surgical instruments | 3,401 | 0.07 | 25,239 | 7,351 |
| 32 | Sports and athletic goods | 17,553 | 0.38 | 23,486 | 5,811 |
| 33 | Miscellaneous industries | 1,626 | 0.04 | 118,469 | 81,675 |
| | Subtotal: manufacturing | 654,326 | 14.13 | (41,998) | (8,396) |
| 34 | Electricity, gas, water supply | 42,784 | 0.92 | 38,736 | 22,111 |
| 35 | Construction | 100,663 | 2.17 | 67,075 | 23,773 |
| | Subtotal: secondary | 797,773 | 17.23 | (45,065) | (11,072) |
| 36 | Trade, transport, and storage | 546,973 | 11.81 | 25,305 | 15,812 |
| 37 | Other services | 613,024 | 13.24 | 10,621 | 5,700 |
| 38 | Banking and insurance | 37,897 | 0.82 | 28,064 | 23,142 |
| 39 | Real estate and ownership of dwellings | 25,370 | 0.55 | 31,921 | 20,891 |
| | Subtotal: tertiary | 1,223,264 | 26.42 | (18,169) | (11,077) |
| | Total | 4,630,863 | 100.00 | (19,003) | (9,151) |

Source: Based on Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Notes: Figures in parentheses are mean values. Parts may not add to totals because of rounding.

sectors than in the labor-intensive agricultural sectors in both 1969/70 and 1979/80. Thus, in 1969/70 the productivity in manufacturing was about three and a half times the output of Rs 4,873 per worker in agriculture. In 1979/80 productivity in the manufacturing sectors was Rs 41,998 compared with an average productivity of Rs 12,242 per worker in agriculture. Overall productivity in the tertiary sector was higher than that in the primary sector but much lower than that in the secondary sector.

There are large variations in productivity per worker within the primary, secondary, and tertiary sectors. Within agriculture, for example, output per worker in the production of wheat, sugarcane, and oilseeds, where new technology has been adopted, is much higher than that for most other crops. In 1979/80, the highest per worker productivity among all the crops was in oilseeds, even though in 1969/70 oilseeds ranked fairly low in labor productivity. The main reason is that over this period the relative prices of oilseeds vis-à-vis other agricultural crops rose at a much higher rate.

The output per worker in animal husbandry shown in Tables 15 and 16 is quite low both for 1969/70 and 1979/80. This is primarily because reliable data on workers and person-days are not available, since animal husbandry is a part-time activity. The estimates have therefore been derived from certain assumptions, giving only a notional value of productivity to this sector.

Within manufacturing, too, there are large variations in labor productivity. In 1969/70 the highest output per worker was in manufacturing of dairy products, followed by basic chemicals, grain mill products, cotton ginning, and basic metal industries. In 1979/80, basic chemicals, including fertilizers, had the highest rank in output per worker, followed by edible oils, grain mill products, miscellaneous industries, and breweries. The lowest output per worker was in printing and publishing and bakery products. Sawmills and manufacture of motor vehicles and parts continued to have low productivity. Within the secondary sector, both construction and electricity showed a high level of labor productivity. In the tertiary sector, output per worker was very low in services but was notably above average in trade and transport, banking, and real estate and dwellings.

The intrasectoral variations in labor productivity, though quite significant, are much lower when labor productivity is measured in terms of value added per worker instead of value of output per worker. Thus, within the primary sector, value added per worker ranged between Rs 1,213 and Rs 5,495 in 1969/70 and between Rs 6,306 and Rs 9,921 in 1979/80 (except for oilseeds, with nearly Rs 15,000). In the manufacturing sector, in 1969/70 the highest value added per worker was Rs 31,654 in the basic chemicals sector. Dairy products, which ranked highest in output per worker, had a value added productivity of only Rs 8,553. Value added per worker in other manufacturing sectors ranged between Rs 1,892 and Rs 6,774. In 1979/80 the highest value added per worker was in miscellaneous industries, followed by basic chemicals and dairy products. For other manufacturing sectors, value added per worker was between Rs 4,656 and Rs 18,853. The range was much higher for value of output per worker in these industries. Value added per worker was high in both construction and electricity during 1979/80.

In the tertiary sector, in 1979/80 value added per worker was quite high in trade and transport, banking, and real estate, while it was rather low in other services.

## Changes in the Pattern of Final Demand

Table 17 shows how final demand was met in Punjab in 1969/70 and 1979/80 and, for comparison, in India in 1979/80. In both 1969/70 and 1979/80 a major

### Table 17—Distribution of final expenditure in Punjab, 1969/70 and 1979/80, and in India, 1979/80

| Item | Punjab | | | | India | |
|---|---|---|---|---|---|---|
| | 1969/70 | | 1979/80 | | 1979/80 | |
| | Expenditure | Distribution | Expenditure | Distribution | Expenditure | Distribution |
| | (Rs million) | (percent) | (Rs million) | (percent) | (Rs million) | (percent) |
| Household consumption | 8,560 | 61.1 | 29,215 | 63.4 | 742,880 | 73.2 |
| Government consumption | 670 | 4.8 | 2,420[a] | 5.3 | 110,250 | 10.9 |
| Gross fixed capital formation | 2,150 | 15.3 | 10,461 | 22.7 | 213,070 | 21.2 |
| Changes in stocks | 300 | 2.1 | 1,211 | 2.6 | 48,360 | 4.8 |
| Net of trade | 3,355 | 23.9 | 7,739 | 16.8 | −17,540 | −1.7 |
| Exports | 6,910 | 49.3 | 37,000 | 80.3 | 83,400 | 8.3 |
| Imports[b] | −3,555 | −25.4 | −29,261 | −63.5 | −100,940 | −10.0 |
| Errors | −1,015 | −7.2 | −4,995 | −10.8 | −21,600 | −1.8 |
| Gross domestic product at market prices | 14,020 | 100.0 | 46,090 | 100.0 | 1,075,420 | 100.0 |

Sources: Based on Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980); Punjab input-output table for 1979/80 (Table 44, Appendix 1); and India, Ministry of Planning, *National Accounts Statistics* (Delhi: Controller of Publications, 1983).

Note: Parts may not add to totals because of rounding.

[a] In the Punjab input-output table, government expenditure is Rs 409.3 million, as it does not include value added to the government sector, which is given as Rs 2,010.4 million for 1979/80, according to the Economic and Functional Classification of the Budget. This amount has been included in value added in public administration and other services (sector 37).

[b] Includes noncompetitive imports amounting to Rs 1,305.9 million in 1969/70 and Rs 6,270.4 million in 1979/80.

part of the "domestic" expenditure net of trade was incurred for private household consumption, followed by gross fixed capital formation.

Instead of taking various components of fixed expenditure as a proportion of total final demand, it is perhaps more useful to obtain its distribution by treating GDP at market prices as the base. In 1969/70, according to the Economic and Statistical Adviser to the Punjab government, at current prices, GDP at market prices was slightly more than Rs 14.0 billion and in 1979/80 it was almost Rs 46.1 billion. According to the input-output accounting matrix, the GDP at market prices for 1979/80 is the total of net value added, depreciation, and taxes net of subsidies (Appendix 1, Table 44, last column). It works out to Rs 46.9 billion in 1979/80, indicating that there is only a very small percentage error in the authors' estimate. The GDP figures of nearly Rs 14.0 billion for 1969/70 and Rs 46.1 billion for 1979/80 given by the Economic and Statistical Adviser are used for the following discussion.

In 1979/80, 63.4 percent of the total expenditure in Punjab was on household consumption (Table 17). This percentage is much lower than the all-India average of 69.1 percent of total GDP spent on consumption. It is significant that the total gross fixed capital formation (including changes in stocks), which was 17.4 percent of GDP in 1969/70, increased to 25.3 percent of total GDP in 1979/80, comparing favorably with the all-India figure of 24.3 percent.

Exports continue to be extremely important in the economy of Punjab. This is especially true since the advent of the new technology in wheat and rice in the mid-1960s. Whereas exports constituted 49.3 percent of GDP in 1969/70, their share increased to 80.3 percent in 1979/80. The share of imports also increased from 25.4

percent to 63.5 percent, indicating an increasing linkage between the Punjab economy and the national economy.

## Household Consumption

In both 1969/70 and 1979/80, household consumption was by far the most important component of final demand, accounting for nearly two-thirds of NSDP. Tables 18 and 19 show the annual per capita consumption expenditure of rural and urban households along with its composition. In nominal terms, per capita consumption expenditure in the rural and urban areas in 1969/70 was Rs 636 and Rs 695, respectively, and increased to Rs 1,744 and Rs 1,936, respectively, in 1979/80.

The composition of expenditure shows that although cereals, including grain mill products, are the most important components of consumption, their share in the total expenditure for rural households dropped from 26.9 percent in 1969/70 to 15.0 percent in 1979/80. In the consumption basket of urban household expenditure, cereals and grain mill products declined from 26.8 percent to 13.8 percent. While there was a notable fall in the proportion of expenditure on milk and dairy products by rural households, from 32.0 percent in 1969/70 to 19.5 percent in 1979/80, the expenditure on milk by urban households declined only slightly, from 19.5 percent in 1969/70 to 16.8 percent in 1979/80. It appears that the expenditure on animal husbandry products by rural households obtained from the Punjab Economic and Statistical Organization was overestimated in the state sample of the round of the National Sample Survey for 1969/70, which constituted the basis for estimates in the present study. The combined state and central sample for 1968/69 shows that rural households spent 22.2 percent—not the 32.0 percent shown in Table 18 for 1969/70—of their expenditure on dairy products compared with 19.5 percent in 1979/80 (India, Ministry of Planning 1979, 1986a, 1986b). Cereals and milk, as well as edible oils, sugar, and cloth, remained important components of consumption expenditure for both rural and urban households.

A notable change was a substantial increase in the proportion of expenditure on trade and transport, banking and insurance, other services, and real estate by rural households in 1979/80. For rural households, the share of expenditure on these tertiary activities substantially increased from 12.4 percent in 1969/70 to 22.1 percent in 1979/80.[9] During the same period, the share spent on these activities by urban households increased only marginally from 20.0 percent to 20.5 percent.

Except for the change in expenditure on the tertiary sector, the relative priorities attached to individual commodity groups in both urban and rural areas remained more or less unchanged between 1969/70 and 1979/80. The first and second priorities were expenditures on cereals and milk, followed by sugar, salt, and other food and nonfood items, indicating that the consumption pattern in both rural and urban Punjab continued to be heavily food-oriented and that there was no significant difference in the consumption basket between rural and urban households. But a perceptible decline in the proportion of expenditure on cereals indicates that, with a rise in per capita income, the consumption pattern became more diversified.

The temporal changes in the consumption pattern are shown in Table 20, which gives the distribution of monthly per capita expenditure by rural households in Punjab

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[9] The 1969/70 input-output table (see Table 13) does not contain any data on banking, insurance services, and real estate. But the distribution of per capita expenditure of rural households given in the 27th round (1972/73) shows that the percentage of expenditure incurred on "services" was 12.4 percent. See India, Ministry of Planning 1979.

## Table 18—Per capita consumption expenditure and its distribution in Punjab, 1969/70

| Sector Number | Sector | Per Capita Expenditure |  | Distribution |  |
|---|---|---|---|---|---|
|  |  | Rural | Urban | Rural | Urban |
|  |  | (Rs) |  | (percent) |  |
| 1 | Wheat | 134.76 | 85.06 | 21.19 | 12.25 |
| 2 | Rice | [a] | [a] | [a] | [a] |
| 3 | Maize | 16.10 | 3.37 | 2.53 | 0.49 |
| 4 | Cotton | [a] | [a] | [a] | [a] |
| 5 | Sugarcane | 18.59 | 3.12 | 2.92 | 0.45 |
| 6 | Gram and pulses | 7.14 | 7.77 | 1.12 | 1.12 |
| 7 | Oilseeds | [a] | [a] | [a] | [a] |
| 8 | Bajra | [a] | [a] | [a] | [a] |
| 9 | Other agriculture and forestry | 50.46 | 57.59 | 7.93 | 8.29 |
| 10 | Animal husbandry | 203.13 | 135.24 | 31.94 | 19.47 |
| 11 | Dairy products | 0.36 | 0.05 | 0.06 | 0.01 |
| 12 | Grain mill products | 19.89 | 97.40 | 3.13 | 14.02 |
| 13 | Sugar and confectionery | 11.91 | 19.25 | 1.87 | 2.77 |
| 14 | Edible oils and other food-processing industries | 15.68 | 25.55 | 2.46 | 3.68 |
| 15 | Breweries and beverages | 12.15 | 10.71 | 1.91 | 1.54 |
| 16 | Textiles | 36.12 | 26.88 | 5.68 | 3.87 |
| 17 | Cotton ginning, pressing, and other textiles | [a] | [a] | [a] | [a] |
| 18 | Sawmills and wooden containers | [a] | [a] | [a] | [a] |
| 19 | Furniture and fixtures | [a] | 0.08 | [a] | 0.01 |
| 20 | Printing and publishing | 2.60 | 5.14 | 0.41 | 0.74 |
| 21 | Rubber and leather products | 10.65 | 6.86 | 1.67 | 0.99 |
| 22 | Basic chemicals, including fertilizers | 1.23 | 0.91 | 0.19 | 0.13 |
| 23 | Other chemicals | 26.94 | 27.51 | 4.24 | 3.96 |
| 24 | Glass and mineral products | 0.38 | 0.17 | 0.06 | 0.24 |
| 25 | Basic metal industries | [a] | [a] | [a] | [a] |
| 26 | Metal products | 0.24 | 0.56 | 0.04 | 0.08 |
| 27 | Machinery, except electrical | 0.43 | 0.20 | 0.07 | 0.03 |
| 28 | Electrical machinery | 0.82 | 0.89 | 0.13 | 0.13 |
| 29 | Railroad equipment | [a] | [a] | [a] | [a] |
| 30 | Transport equipment | [a] | [a] | [a] | [a] |
| 31 | Repair of transport equipment | [a] | [a] | [a] | [a] |
| 32 | Motorcycles and bicycles | 2.52 | 2.46 | 0.40 | 0.35 |
| 33 | Scientific and surgical instruments | [a] | [a] | [a] | [a] |
| 34 | Miscellaneous industries | 3.16 | 4.68 | 0.50 | 0.67 |
| 35 | Construction | [a] | [a] | [a] | [a] |
| 36 | Electricity | 1.54 | 7.83 | 0.24 | 0.67 |
|  | Subtotal | 576.80 | 529.30 | 90.69 | 76.21 |
|  | Trade margins | 37.67 | 125.61 | 5.92 | 18.08 |
|  | Taxes, duties, and subsidies | 0.68 | 1.72 | 0.11 | 0.25 |
|  | Fuels and lubricants | 8.00 | 27.30 | 1.26 | 3.93 |
|  | Other noncompetitive imports | 12.91 | 10.66 | 2.03 | 1.54 |
|  | Total | 636.06 | 694.59 | 100.00 | 100.00 |

Source: Based on Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

Note: Parts may not add to totals because of rounding.

[a] Data are unavailable, as these commodities do not directly enter into the consumption basket.

on major commodity groups over various National Sample Survey rounds. As indicated earlier, the proportion of expenditure on foods declined rapidly after 1973/74. Within the food group, while expenditure on cereals declined, there was an increase in expenditure on noncereal foods, particularly beverages and refreshments. The percentage of expenditure on nonfoods increased substantially over time, particularly for alcoholic beverages, clothing, and other nonfood items.

## Table 19—Per capita consumption expenditure and its distribution in Punjab, 1979/80

| Sector Number | Sector | Per Capita Expenditure |  | Distribution |  |
|---|---|---|---|---|---|
|  |  | Rural | Urban | Rural | Urban |
|  |  | (Rs) |  | (percent) |  |
| 1 | Wheat | 116.63 | 120.56 | 6.69 | 6.23 |
| 2 | Rice | 18.94 | 9.79 | 1.09 | 0.51 |
| 3 | Cotton | [a] | [a] | [a] | [a] |
| 4 | Sugarcane | 43.47 | 3.62 | 2.49 | 0.19 |
| 5 | Gram and pulses | 42.70 | 41.21 | 2.45 | 2.13 |
| 6 | Oilseeds | [a] | [a] | [a] | [a] |
| 7 | Other agriculture and forestry | 159.61 | 189.82 | 9.15 | 9.81 |
| 8 | Animal husbandry | 271.10 | 273.85 | 15.55 | 14.15 |
| 9 | Dairy products and confectionery | 68.12 | 50.43 | 3.91 | 2.61 |
| 10 | Grain mill products | 126.13 | 136.20 | 7.23 | 7.04 |
| 11 | Bakery products | 6.56 | 24.74 | 0.38 | 1.28 |
| 12 | Sugar | 34.73 | 54.47 | 1.99 | 2.81 |
| 13 | Other food industries | 31.37 | 13.01 | 1.80 | 0.67 |
| 14 | Edible oils | 49.38 | 81.82 | 2.83 | 4.23 |
| 15 | Breweries and beverages | 22.20 | 43.28 | 1.27 | 2.24 |
| 16 | Ginning and textiles | 119.30 | 92.01 | 6.84 | 4.75 |
| 17 | Sawmills and wooden goods | 4.17 | 1.86 | 0.24 | 0.10 |
| 18 | Paper, printing, and publishing | 13.76 | 22.88 | 0.79 | 1.18 |
| 19 | Rubber and leather products | 39.11 | 31.30 | 2.24 | 1.62 |
| 20 | Basic chemicals, including fertilizers | 1.19 | [a] | 0.07 | [a] |
| 21 | Drugs and pharmaceuticals | 67.44 | 81.01 | 3.87 | 4.19 |
| 22 | Other chemicals | 55.17 | 85.37 | 3.18 | 4.41 |
| 23 | Glass and mineral products | 1.62 | 0.66 | 0.09 | 0.03 |
| 24 | Basic metal industries | 1.64 | [a] | 0.09 | [a] |
| 25 | Metal products | 4.20 | 1.66 | 0.24 | 0.09 |
| 26 | Machinery, except electrical | 3.26 | 3.52 | 0.18 | 0.18 |
| 27 | Electrical machinery | 4.39 | 9.91 | 0.25 | 0.51 |
| 28 | Railroad equipment | [a] | [a] | [a] | [a] |
| 29 | Motor vehicles, manufacture and repair | [a] | 0.46 | [a] | 0.02 |
| 30 | Bicycles and parts | 0.65 | 1.28 | 0.04 | 0.07 |
| 31 | Scientific and surgical instruments | [a] | [a] | [a] | [a] |
| 32 | Sports and athletic goods | 0.10 | 0.31 | 0.01 | 0.02 |
| 33 | Miscellaneous industries | 8.04 | 2.48 | 0.46 | 0.13 |
| 34 | Electricity, gas, water supply | 15.66 | 52.27 | 0.90 | 2.70 |
| 35 | Construction | 1.41 | 5.03 | 0.08 | 0.26 |
| 36 | Trade, transport, and storage | 285.47 | 228.65 | 16.37 | 11.81 |
| 37 | Other services | 37.78 | 105.00 | 2.17 | 5.42 |
| 38 | Banking and insurance | 9.97 | 11.07 | 0.57 | 0.57 |
| 39 | Real estate and ownership of dwellings | 48.60 | 52.92 | 2.97 | 2.73 |
|  | Noncompetitive imports | 28.65 | 101.69 | 1.64 | 5.25 |
|  | Taxes and duties | 1.12 | 1.63 | 0.06 | 0.08 |
|  | Total | 1,743.64 | 1,935.77 | 100.00 | 100.00 |

Source: Based on Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Note: Parts may not add to totals because of rounding.
[a] Data are unavailable, as these commodities do not directly enter into the consumption basket.

Since detailed household schedules of expenditure are not available, it is not possible to use the available data to directly derive the consumption elasticities for various commodities. In an earlier study (Bhalla and Chadha 1983) these elasticities were derived on the basis of a survey of 1,663 rural households conducted in 1975/76. As expected, while the expenditure elasticities were high for clothing (1.8-1.9), footwear (1.5-1.6), services (1.2-1.3), milk and milk products (1.3-1.4), and beverages (1.4-1.6), they were quite low for cereals, edible oils, and other essentials. Details are given in Table 21.

## Table 20—Distribution of average monthly per capita expenditure on major commodity groups in rural Punjab, 1964/65-1983

| Commodity Group | 1964/65 | | 1966/67 | | 1968/69 | | 1973/74 | | 1977/78 | | 1983 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Expenditure | Percentage | Expenditure | Percentage | Expenditure | Percentage | Expenditure | Percentage | Expenditure | Percentage | Expenditure | Percentage |
| | (Rs) | | (Rs) | | (Rs) | | (Rs) | | (Rs) | | (Rs) | |
| Cereals and cereal substitutes | 9.14 | 25.24 | 12.19 | 26.50 | 12.78 | 22.60 | 15.10 | 20.00 | 16.55 | 17.71 | 24.88 | 14.58 |
| Pulses and pulse products | 1.14 | 3.15 | 1.43 | 3.11 | 1.56 | 2.76 | 2.38 | 3.15 | 2.90 | 3.10 | 5.05 | 2.96 |
| Milk and milk products | 7.00 | 19.33 | 9.34 | 20.31 | 12.02 | 21.15 | 16.01 | 21.20 | 21.97 | 23.51 | 31.11 | 18.23 |
| Edible oils | 0.88 | 2.43 | 1.12 | 2.44 | 1.53 | 2.71 | 2.59 | 3.43 | 3.22 | 3.45 | 5.99 | 3.51 |
| Meat, eggs, and fish | 0.32 | 0.89 | 0.33 | 0.72 | 0.58 | 1.03 | 0.93 | 1.23 | 0.93 | 1.00 | 1.78 | 1.04 |
| Fruit and vegetables | 1.24 | 3.42 | 1.31 | 2.85 | 1.82 | 3.22 | 3.60 | 4.77 | 3.48 | 3.72 | 8.73 | 5.12 |
| Sugar, salt, and spices | 3.58 | 9.88 | 3.99 | 8.67 | 6.47 | 11.43 | 8.80 | 11.65 | 8.63 | 9.24 | 14.23 | 8.34 |
| Beverages and refreshments | 1.19 | 3.29 | 1.10 | 2.39 | 1.70 | 3.00 | 2.88 | 3.82 | 3.64 | 3.90 | 8.36 | 4.90 |
| Total food | 24.49 | 67.62 | 30.81 | 66.98 | 38.46 | 68.00 | 52.29 | 69.25 | 61.32 | 65.63 | 100.13 | 58.68 |
| Betel leaf, tobacco, and alcoholic beverages | 0.66 | 1.82 | 0.75 | 1.63 | 1.37 | 2.42 | 2.45 | 3.25 | 2.12 | 2.27 | 4.01 | 2.35 |
| Clothing | 3.29 | 9.08 | 2.38 | 5.17 | 5.03 | 8.89 | 6.75 | 8.94 | 8.62 | 9.23 | 19.86 | 11.64 |
| Fuel and light | 1.95 | 5.38 | 2.28 | 4.96 | 3.00 | 5.31 | 4.07 | 5.38 | 5.68 | 6.08 | 11.68 | 6.84 |
| Consumer durables | 0.94 | 2.60 | 0.86 | 1.87 | 1.86 | 3.29 | 1.81 | 2.40 | 2.90 | 3.10 | 4.45 | 2.61 |
| Other nonfood items | 4.89 | 13.50 | 8.92 | 19.39 | 6.84 | 12.09 | 8.14 | 10.78 | 12.79 | 13.69 | 30.52 | 17.88 |
| Total nonfood | 11.73 | 32.38 | 15.19 | 33.02 | 18.10 | 32.00 | 23.22 | 30.75 | 32.11 | 34.37 | 70.52 | 41.32 |
| Total expenditure | 36.22 | 100.00 | 46.00 | 100.00 | 56.56 | 100.00 | 75.51 | 100.00 | 93.43 | 100.00 | 170.65 | 100.00 |

Sources: India, Ministry of Planning, National Sample Survey Organization, *Sarvekshana* 2 (January 1979); India, Ministry of Planning, NSSO, *Sarvekshana* 9 (January 1986); India, Ministry of Planning, NSSO, *Sarvekshana* 9 (April 1986); and 1977/78 data obtained from the Office of the Economic Adviser, Government of Punjab, through the courtesy of J. S. Kapur, director of the National Sample Survey Organization.

Note: Parts may not add to totals because of rounding.

Table 21—Commodity expenditure elasticities for cultivating households in rural Punjab, 1974/75

| Commodity Group | Range for Expenditure Elasticity[a] (e) | Range for Coefficient of Determination ($r^2$) | Saturation Limit for per Capita Expenditure[b] | | Cash Spent as a Percentage of Total Expenditure |
|---|---|---|---|---|---|
| Cereals and cereal products | 0.22–0.24 | 0.16–0.18 | 242.30 | (195.10) | 6.76 |
| Pulses | 0.49–0.56 | 0.14–0.18 | 42.95 | (27.30) | 79.08 |
| Milk and milk products | 1.32–1.40 | 0.80–0.86 | 705.73 | (304.27) | 3.50 |
| Edible oils | 0.23–0.30 | 0.01–0.02 | n.a. | n.a. | 78.83 |
| Meat, eggs, and fish | 3.02–3.31 | 0.44–0.49 | 145.17 | (9.01) | 83.67 |
| Vegetables and fruit | 0.52–0.61 | 0.15–0.20 | 55.70 | (34.51) | 78.83 |
| Sugar and gur | 0.72–0.73 | 0.63–0.65 | 144.03 | (70.47) | 70.66 |
| Salt and spices | 0.13–0.15 | 0.01–0.01 | 21.54 | (14.75) | 100.00 |
| Beverages | 1.37–1.63 | 0.54–0.68 | 165.67 | (36.54) | 100.00 |
| Fuel and light | 0.24–0.25 | 0.13–0.15 | 59.74 | (45.69) | 17.81 |
| Clothing | 1.76–1.92 | 0.65–0.70 | 566.80 | (77.18) | 100.00 |
| Footwear | 1.54–1.57 | 0.40–0.43 | 112.17 | (18.39) | 100.00 |
| Miscellaneous goods and services | 1.23–1.30 | 0.54–0.61 | 399.41 | (70.88) | 100.00 |

Sources: G. S. Bhalla and G. K. Chadha, *Green Revolution and the Small Peasant: A Study of Income Distribution among Punjab Cultivators* (New Delhi: Concept, 1983), 138-140; and G. K. Chadha, *The State and Rural Economic Transformation: The Case of Punjab, 1950-85* (New Delhi: Sage, 1986), 336.

Note: n.a. means not available.

[a] For each commodity group, expenditure elasticity has been worked out from four types of Engel functions (semilog, hyperbolic, log-linear, and log-inverse). The lowest and highest values of the elasticity thus constitute the range for (e).

[b] The saturation limit for commodity expenditure (computed mostly from log-inverse function) corresponds to an infinitely large level of total per capita expenditure; it is the value of the upper asymptote. The figures in parentheses are per capita expenditures actually incurred.

In sum, consumption expenditure continued to be the most important component of final demand in 1979/80. A rapid increase in per capita income also resulted in increased expenditure on consumption by both rural and urban households. Despite some minor differences, expenditure by both rural and urban households continued to be highly oriented toward food items, as is typical of the consumption pattern in developing countries.

### Gross Fixed Capital Formation and Changes in Stocks

For 1979/80, gross fixed capital formation is estimated at almost Rs 10.5 million and changes in stocks at more than Rs 1.2 million, and the two together constitute 25.3 percent of GDP at market prices. This proportion is much higher than that in 1969/70, when only 15.3 percent of GDP was spent on capital formation and 2.1 percent on changes in stocks. In 1979/80, the proportion of income spent on gross domestic capital formation in Punjab was comparable to that in all of India.

A notable feature of the composition of gross capital formation in the state is that, compared with 54.8 percent in 1969/70, expenditure on construction accounted for as much as 65.1 percent of total gross fixed capital formation in 1979/80. On the other hand, investments in nonelectrical and electrical machinery constituted only 17.3 percent and 3.8 percent, respectively, of gross capital formation. In the country as a whole, construction constituted 53.4 percent of the total expenditure on gross fixed capital formation during 1979/80.

The much higher allocation of investment expenditure on construction in Punjab than in all of India can be explained by certain specific features of development in the state. During the 1960s, because of exceptionally high levels of profitability in the adoption of new technology, the cultivators undertook large investments in tubewells, tractors, other agricultural machinery, farm houses, and other construction. Since the life of agricultural machinery is quite long and a great deal of investment was undertaken during the 1960s and 1970s, further investment in machinery seems to be petering out.

Further, during the late 1970s, gross fixed investment in agriculture was characterized by an unusually high component of construction. For example, a room is normally constructed along with a tubewell, and a shed accompanies the purchase of a tractor. Large investments have also been undertaken in the construction of godowns and warehouses by both the central and the state governments, by public sector agencies, and by private individuals for the storage of wheat and rice surpluses. Finally, in the socioeconomic context of Punjab, where a very high priority is accorded to residential houses, increased incomes have resulted in larger investments in residential construction.

### Exports and Imports

The Punjab continues to be a highly export-surplus economy. In 1979/80 exports constituted as much as 80.3 percent of the total GDP compared with 49.3 percent in 1969/70 (Table 17). On the other hand, the share of imports also increased—to 63.5 percent of GDP in 1979/80 from only 25.4 percent in 1969/70. But despite large imports in 1979/80, the balance of trade had a net surplus of more than Rs 7.7 billion, or 16.8 percent of GDP. In 1969/70, the net surplus of the economy was almost Rs 3.4 billion, or 23.9 percent of GDP. Agricultural commodities continue to be important in the export basket; in 1979/80 they constituted 33.8 percent of all exports. Animal husbandry contributed another 6.4 percent to total exports. Within the agricultural sector, wheat and rice together accounted for 27.3 percent of total exports from the state.

During the 1970s some of the manufacturing industries also made significant contributions to exports, and some of these found an export market not only in the rest of India but in foreign countries as well. Consequently, manufactures remained important in the export market, contributing nearly 43 percent to total exports compared with about 42 percent in 1969/70. Within manufacturing, the sectors that contributed fairly large proportions to exports are basic metals and alloys (8.8 percent), other chemicals (9.9 percent), textiles (5.0 percent), bicycles (3.3 percent), and motor vehicles (1.9 percent). Large exports also took place from the tertiary sector, with trade and transport accounting for 5.9 percent and other services for 11.5 percent of total exports from Punjab.

With modernization of agriculture and industry, growth of income, and a growing interrelationship with the rest of the country, imports have also risen at a rapid rate. For example, at current prices, competitive imports amounted to more than Rs 2.2 billion and noncompetitive imports to about Rs 1.3 billion in 1969/70. The total imports into the state's economy in 1979/80 were almost Rs 23.0 billion for competitive and Rs 6.3 billion for noncompetitive imports. As is to be expected, a major proportion of imports were used up as inputs for agricultural production, followed by industrial production. For example, the largest imports were those of basic chemicals and fertilizers and other chemicals, which accounted for 29 percent of total imports into Punjab. These were followed by basic metals and alloys, electrical and nonelectrical machinery, and nonmetallic mineral products. As in 1969/70, most of the noncompetitive imports consisted of diesel oil, petrol, and other petroleum products.

A peculiar feature of the manufacturing sector in Punjab is that because of nonavailability of raw materials, except in agriculture-based industry, most of the industrial raw materials such as iron and steel, coal, diesel, and petroleum needed for basic metals, machine tools, and durable consumer goods industries are imported from the rest of India. These raw materials are used to produce manufactured goods that are primarily exported to the rest of the country. A significant development that has resulted in considerable reduction in imports is the establishment of two large fertilizer plants in the public sector in Punjab.

Within the consumption basket, imports included drugs and pharmaceuticals (7.8 percent); other agriculture, mainly wood (5.5 percent); dairy products and confectionery (4.0 percent); edible oils (3.6 percent); sugar (2.5 percent); rubber and leather products (3.0 percent); and textiles (4.7 percent).

# 5

# LINKAGE ANALYSIS OF THE PUNJAB ECONOMY

The Punjab input-output tables for 1969/70 (Alagh, Bhalla, and Kashyap 1980) and 1979/80 (Appendix 1, Table 44) were used in Chapter 4 to analyze the main features and changes in the structure of the Punjab economy during 1969/70-1979/80. One of the important uses of an input-output table is to lay bare the structure of production in an economy and the interdependencies between various sectors.

This chapter examines the nature and extent of sectoral interdependence in Punjab through calculation of the direct and indirect input use and output disposal of each sector. In particular, an attempt will be made to quantify the relationship between agriculture and the nonagricultural sectors of the Punjab economy.

Some notable attempts have been made to analyze the relationship between agricultural growth and industrial development by defining the major points of influence and by quantifying the various relationships between the two sectors (see Rangarajan 1982). It is beyond the scope of this report to build an econometric model with a new view to undertaking a comprehensive study of production, demand, and savings and investment types of linkages through which agriculture influences industry or vice versa. However, the input-output analysis does permit quantification of the extent of intersectoral interdependence, including backward and forward linkages.

An input-output table only quantifies the direct and indirect dependence of various sectors on one another within a general equilibrium framework without implying any causality of relationships. It appears that some of the causal hypotheses advanced by some scholars using this framework may lack much theoretical validity.

Before an in-depth analysis of the pattern of linkages is undertaken for all 39 sectors in the 1979/80 Punjab input-output table, an overview of the interrelationships among various sectors in the Punjab economy is provided by aggregating the 39 sectors into only 5 sectors. The Indian input-output table for 1979/80 (India, Planning Commission 1981) has also been condensed into 5 equivalent sectors to bring out the main differences in the structure of production in Punjab and in India as a whole. This is followed by a detailed analysis of changes in the linkage patterns in Punjab during 1969/70-1979/80. The pattern of backward and forward linkages and changes therein have been studied by use of the Rasmussen method, working out Rasmussen indices separately for 1969/70 and 1979/80 for all the disaggregated sectors contained in the Punjab input-output tables for these years.

## An Overview of Agriculture-Nonagriculture Linkages

The extent of intersectoral linkages depends on the density of the input structure of various sectors in an economy. That the production structure of agriculture in Punjab is different from that in the rest of the country is brought out by a comparison of the condensed five-sector input-output flow and coefficient tables for Punjab and India for 1979/80 (Tables 22-25). Some of the differences are detailed below.

First, whereas intermediate inputs (including such inputs as noncompetitive imports) constituted 24.8 percent of the value of agricultural output in India, their share was

# Table 22—Interindustrial flows and patterns of final demand in Punjab, 1979/80

| Item | Agriculture and Allied Industries | Manufacturing and Allied Industries | Trade, Transport, and Storage | Banking and Insurance | Public and Other Services | Total Interme-diate Use | Private Consumption | | Government Consump-tion |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Rural | Urban | |
| | | | | | (Rs 1,000)[a] | | | | |
| Agriculture and allied industries | 2,238,900 | 3,790,010 | 60,198 | 0 | 201,771 | 6,290,879 | 7,762,995 | 2,794,962 | 25,391 |
| Manufacturing and allied industries | 3,639,381 | 13,406,580 | 837,004 | 12,432 | 1,326,917 | 19,222,320 | 8,085,507 | 3,482,375 | 180,544 |
| Trade, transport, and storage | 573,467 | 4,055,336 | 1,430,546 | 33,862 | 773,282 | 6,866,493 | 3,396,441 | 1,000,401 | 79,370 |
| Banking and insurance | 97,821 | 319,818 | 318,637 | 83,191 | 47,529 | 866,996 | 118,676 | 48,477 | 0 |
| Public and other services | 0 | 0 | 971,217 | 18,208 | 346,613 | 1,336,038 | 1,027,926 | 690,903 | 0 |
| Total inputs | 6,549,569 | 21,571,750 | 3,617,602 | 147,693 | 2,696,112 | 34,582,720 | 20,391,540 | 8,017,118 | 285,305 |
| Noncompetitive imports | 2,060,152 | 2,425,777 | 567,093 | 1,252 | 21,734 | 5,076,008 | 340,863 | 444,905 | 79,016 |
| Repair and maintenance | 189,200 | 557,736 | 0 | 0 | 0 | 746,936 | 0 | 0 | 24,684 |
| Work done by others | 0 | 780,782 | 0 | 0 | 0 | 780,782 | 0 | 0 | 0 |
| Taxes, duties, and subsidy | 232,007 | 466,989 | 414,031 | 4,183 | 245,922 | 1,363,132 | 13,298 | 7,077 | 0 |
| Consumable stores | 0 | 578,930 | 0 | 0 | 0 | 578,930 | 0 | 0 | 0 |
| Depreciation | 759,000 | 775,359 | 593,300 | 33,700 | 332,900 | 2,494,259 | 0 | 0 | 20,295 |
| Net value added | 19,995,750 | 8,833,328 | 8,649,200 | 876,700 | 4,023,800 | 42,378,780 | 0 | 0 | 0 |
| Gross output | 29,785,680 | 35,990,650 | 13,841,230 | 1,063,528 | 7,320,468 | 88,001,550 | 20,745,710 | 8,469,100 | 409,300 |
| Workers (in number of persons) | 2,609,826 | 797,773 | 546,973 | 37,897 | 638,394 | 4,630,863 | 0 | 0 | 0 |
| Person-days (in thousands of days) | 681,164 | 232,063 | 171,203 | 10,611 | 187,278 | 1,282,319 | 0 | 0 | 0 |
| Wages | 5,571,936 | 4,589,304 | 5,602,138 | 457,900 | 3,079,880 | 19,301,160 | 0 | 0 | 0 |

| Item | Capital Formation | Change in Stocks | Exports | Imports | Final Demand | Gross Output |
|---|---|---|---|---|---|---|
| | | | (Rs 1,000)[a] | | | |
| Agriculture and allied industries | 234,805 | 460,000 | 14,860,680 | 2,644,033 | 23,494,800 | 29,785,680 |
| Manufacturing and allied industries | 9,275,284 | 421,600 | 15,669,690 | 20,346,670 | 16,768,330 | 35,990,650 |
| Trade, transport, and storage | 323,838 | 0 | 2,174,683 | 0 | 6,974,733 | 13,841,230 |
| Banking and insurance | 0 | 0 | 29,379 | 0 | 196,532 | 1,063,528 |
| Public and other services | 0 | 0 | 4,265,601 | 0 | 5,984,430 | 7,320,468 |
| Total inputs | 9,833,927 | 881,600 | 37,000,040 | 22,990,700 | 53,418,825 | 88,001,550 |
| Noncompetitive imports | 0 | 329,600 | 0 | 0 | 1,194,384 | 6,270,392 |
| Repair and maintenance | 0 | 0 | 0 | 0 | 24,684 | 771,620 |
| Work done by others | 0 | 0 | 0 | 0 | 0 | 780,782 |
| Taxes, duties, and subsidy | 626,702 | 0 | 0 | 0 | 647,077 | 2,010,209 |
| Consumable stores | 0 | 0 | 0 | 0 | 0 | 578,930 |
| Depreciation | 0 | 0 | 0 | 0 | 20,295 | 2,514,554 |
| Net value added | 0 | 0 | 0 | 0 | 0 | 42,378,780 |
| Gross output | 10,460,630 | 1,211,200 | 37,000,040 | 22,990,700 | 55,305,265 | 143,306,800 |
| Workers (in number of persons) | 0 | 0 | 0 | 0 | 0 | 4,630,863 |
| Person-days (in thousands of days) | 0 | 0 | 0 | 0 | 0 | 1,282,319 |
| Wages | 0 | 0 | 0 | 0 | 0 | 19,301,160 |

Source: Based on Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Note: Parts may not add to totals because of rounding.
[a] Factor cost at 1979/80 prices.

### Table 23—Interindustry coefficient table, Punjab, 1979/80

| Item | Agriculture and Allied Industries | Manufacturing and Allied Industries | Trade, Transport and Storage | Banking and Insurance | Public and Other Services |
|---|---|---|---|---|---|
| Agriculture and allied industries | 0.0752 | 0.1053 | 0.0044 | 0.0000 | 0.0276 |
| Manufacturing and allied industries | 0.1222 | 0.3725 | 0.0605 | 0.0117 | 0.1813 |
| Trade, transport, and storage | 0.0192 | 0.1127 | 0.1033 | 0.0319 | 0.1056 |
| Banking and insurance | 0.0033 | 0.0089 | 0.0230 | 0.0782 | 0.0065 |
| Public and other services | 0.0000 | 0.0000 | 0.0702 | 0.0171 | 0.0473 |
| Total inputs | 0.2199 | 0.5994 | 0.2614 | 0.1389 | 0.3683 |
| Noncompetitive imports | 0.0692 | 0.0674 | 0.0410 | 0.0012 | 0.0030 |
| Repair and maintenance | 0.0064 | 0.0155 | 0.0000 | 0.0000 | 0.0000 |
| Work done by others | 0.0000 | 0.0217 | 0.0000 | 0.0000 | 0.0000 |
| Taxes, duties, subsidy | 0.0078 | 0.0130 | 0.0299 | 0.0039 | 0.0336 |
| Consumable stores | 0.0000 | 0.0161 | 0.0000 | 0.0000 | 0.0000 |
| Depreciation | 0.0255 | 0.0216 | 0.0429 | 0.0317 | 0.0455 |
| Net value added | 0.6713 | 0.2454 | 0.6249 | 0.8243 | 0.5497 |
| Gross output | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Workers | 0.0876 | 0.0222 | 0.0395 | 0.0356 | 0.0872 |
| Person-days | 0.0229 | 0.0065 | 0.0124 | 0.0100 | 0.0256 |
| Wages | 0.1871 | 0.1275 | 0.4047 | 0.4306 | 0.4207 |

Source: Derived from Table 22.
Note: Parts may not add to totals because of rounding.

as high as 28.9 percent in the case of Punjab. Hence, compared with the agricultural sector of India, that of Punjab is likely to generate a higher level of intersectoral linkages.

Second, consequent to adoption of the new technology in agriculture, the share of industrial inputs in the value of agricultural output was much greater, and that of agricultural inputs much smaller, in Punjab than in India as a whole. Industrial inputs, including noncompetitive imports of fuels and lubricants, constituted 19.1 percent of the value of agricultural output and as much as 66.2 percent of the total value of inputs used in agricultural production in the state. In the case of India, industrial inputs accounted for only 8.8 percent of the value of agricultural output and 35.4 percent of the total value of agricultural inputs.

The direct and indirect output effects of changes in final demand from various sectors in Punjab and India can be derived from the respective Leontief inverses in Tables 26-29. Because of lower agricultural input and higher input from manufacturing in agricultural production, one unit of final demand from agriculture results in considerably lower direct and indirect output from agriculture and notably higher output from manufacturing in Punjab than in India. A Rs 1.00 increase in final demand from agriculture led to a Rs 1.11 increase in agricultural output in Punjab compared with Rs 1.15 in India—the increases in manufacturing output were Rs 0.22 in Punjab and Rs 0.18 in India. The changes for other sectors are also given in Tables 26-29.

Third, both in Punjab and in India as a whole, the proportion of agricultural output used as interindustry input is much lower, and that allocated to final consumption much greater, than is the case with manufacturing. In both cases, manufacturing uses much higher amounts of intermediate inputs as a proportion of output than does agriculture. Consequently, manufacturing generates much greater forward and backward linkages than agriculture. Because of this, increases in final demand from manufacturing lead to notably higher levels of direct and indirect output in all the sectors and particularly in manufacturing. In Punjab, an increase of Rs 1.00 in final demand from manufacturing resulted in a direct and indirect output of as much as Rs 1.66 in

## Table 24—Interindustrial flows and patterns of final demand in India, 1979/80

| Item | Agriculture and Allied Industries | Industry and Mining | Transport, Communications, and Trade | Money, Banking, and Real Estate | Public Administration Services | Total Intermediate Use |
|---|---|---|---|---|---|---|
| | | | (Rs million)[a] | | | |
| Agriculture and allied industries | 53,848 | 79,334 | 1,424 | 0 | 6,487 | 141,093 |
| Industry and mining | 40,441 | 303,852 | 36,727 | 5,028 | 52,454 | 438,501 |
| Transport, communications, and trade | 12,519 | 132,697 | 28,682 | 1,043 | 17,908 | 192,847 |
| Money, banking, and real estate | 3,046 | 13,131 | 7,112 | 2,620 | 1,411 | 27,320 |
| Public administration services | 4,312 | 11,954 | 21,679 | 677 | 10,357 | 48,978 |
| Total inputs | 114,164 | 540,967 | 95,623 | 9,368 | 88,617 | 848,739 |
| Indirect tax | 5,848 | 43,175 | 9,242 | 142 | 7,399 | 65,806 |
| Gross value added | 340,945 | 255,935 | 206,304 | 60,335 | 106,990 | 970,509 |
| Gross output | 460,958 | 840,075 | 311,170 | 69,845 | 203,006 | 1,885,054 |

| Item | Private Consumption | Public Consumption | Gross Fixed Investment | Change in Stocks | Exports | Imports | Total Final Use | Gross Output |
|---|---|---|---|---|---|---|---|---|
| | | | | (Rs million)[a] | | | | |
| Agriculture and allied industries | 314,509 | 2,205 | 1,692 | –3,782 | 7,039 | 1,797 | 319,865 | 460,958 |
| Industry and mining | 210,261 | 24,514 | 176,100 | 30.148 | 47,306 | 86,103 | 402,225 | 840,727 |
| Transport, communications, and trade | 79,117 | 10,932 | 19,975 | 0 | 8,301 | 0 | 118,324 | 311,170 |
| Money, banking, and real estate | 41,707 | 717 | 0 | 0 | 100 | 0 | 42,524 | 69,843 |
| Public administration services | 73,447 | 75,708 | 0 | 0 | 4,780 | 0 | 153,935 | 202,913 |
| Total inputs | 719,040 | 114,076 | 197,767 | 26,366 | 67,526 | 87,900 | 1,036,874 | 1,885,611 |
| Indirect tax | 31,490 | 3,494 | 12,603 | 0 | 1,555 | 0 | 49,142 | 114,950 |
| Gross value added | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 970,510 |
| Gross output | 750,530 | 117,570 | 210,370 | 26,366 | 69,080 | 87,900 | 1,086,016 | 2,971,071 |

Source: India, Planning Commission, *A Technical Note on the Sixth Plan of India, 1980-85* (New Delhi: Controller of Publications, 1981), 99.
Note: Parts may not add to totals because of rounding.
[a] Factor cost at 1979/80 prices.

manufacturing, Rs 0.19 in agriculture, and Rs 0.25 in other sectors. In the case of India, the respective output levels were Rs 1.67, Rs 0.18, and Rs 0.39.

Fourth, with changes in final demand, the direct and indirect increases in the output of various sectors are considerably reduced when import leakages are taken into account by using the modified Leontief inverse.[10] The impact of import leakages is much stronger in Punjab than in India because of Punjab's greater dependence on industrial imports for use as inputs in both agriculture and industry.

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[10] Instead of inverting $(I-A)$, one can invert the $(I + \bar{b} - A)$ matrix, where $\bar{b}$ is a diagonal matrix of $b_i$, defined as $b_i = M_i/X_i$, where $M_i$ is imports into sector i and $X_i$ is the output of sector i.

## Table 25—Interindustry coefficient table, India, 1979/80

| Item | Agriculture and Allied Industries | Industry and Mining | Transport, Communi-cations, and Trade | Money, Banking, and Real Estate | Public Adminis-tration Services |
|---|---|---|---|---|---|
| Agriculture and allied industries | 0.1168 | 0.0944 | 0.0046 | 0.0000 | 0.0320 |
| Industry and mining | 0.0877 | 0.3617 | 0.1180 | 0.0720 | 0.2584 |
| Transport, communications, and trade | 0.0272 | 0.1580 | 0.0922 | 0.0149 | 0.0882 |
| Money, banking, and real estate | 0.0066 | 0.0156 | 0.0229 | 0.0375 | 0.0070 |
| Public administration services | 0.0094 | 0.0142 | 0.0697 | 0.0097 | 0.0510 |
| Total inputs | 0.2477 | 0.6439 | 0.3073 | 0.1341 | 0.4365 |
| Indirect taxes | 0.0127 | 0.0514 | 0.0297 | 0.0020 | 0.0365 |
| Gross value added | 0.7396 | 0.3047 | 0.6630 | 0.8639 | 0.5270 |
| Gross output | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

Source: Derived from Table 24.
Note: Parts may not add to totals because of rounding.

## Table 26—Leontief inverse for the Punjab interindustry table, without import leakages, 1979/80

| Sector<br>Inverted Matrix [I−A] | Agriculture and Allied Industries (1) | Manufacturing and Allied Industries (2) | Trade, Transport, and Storage (3) | Banking and Insurance (4) | Public and Other Services (5) |
|---|---|---|---|---|---|
| 1. Agriculture and allied industries | 1.1069 | 0.1901 | 0.0239 | 0.0046 | 0.0709 |
| 2. Manufacturing and allied industries | 0.2219 | 1.6565 | 0.1400 | 0.0321 | 0.3373 |
| 3. Trade, transport, and storage | 0.0524 | 0.2149 | 1.1445 | 0.0454 | 0.1696 |
| 4. Banking and insurance | 0.0074 | 0.0221 | 0.0306 | 1.0865 | 0.0152 |
| 5. Public and other services | 0.0040 | 0.0162 | 0.0849 | 0.0229 | 1.0625 |

## Table 27—Leontief inverse for the Punjab interindustry table, with import leakages, 1979/80

| Sector<br>Inverted Matrix $[I + \hat{b} - A]$ | Agriculture and Allied Industries (1) | Manufacturing and Allied Industries (2) | Trade, Transport, and Storage (3) | Banking and Insurance (4) | Public and Other Services (5) |
|---|---|---|---|---|---|
| 1. Agriculture and allied industries | 0.9977 | 0.0895 | 0.0147 | 0.0025 | 0.0475 |
| 2. Manufacturing and allied industries | 0.1044 | 0.8545 | 0.0722 | 0.0166 | 0.1737 |
| 3. Trade, transport, and storage | 0.0351 | 0.1107 | 1.1356 | 0.0434 | 0.1483 |
| 4. Banking and insurance | 0.0055 | 0.0114 | 0.0297 | 1.0863 | 0.0130 |
| 5. Public and other services | 0.0027 | 0.0084 | 0.0842 | 0.0227 | 1.0609 |

Note: $b_i = M_i/X_i$, where $M_i$ is imports by sector i and $X_i$ is output of sector i.

## Table 28—Leontief inverse for the India interindustry table, without import leakages, 1979/80

| Sector<br>Inverted Matrix $[I-A]$ | Agriculture and Allied Industries (1) | Manufacturing and Allied Industries (2) | Trade, Transport, and Storage (3) | Banking and Insurance (4) | Public and Other Services (5) |
|---|---|---|---|---|---|
| 1. Agriculture and allied industries | 1.1526 | 0.1821 | 0.0369 | 0.0151 | 0.0919 |
| 2. Manufacturing and allied industries | 0.1802 | 1.6715 | 0.2589 | 0.1339 | 0.4862 |
| 3. Trade, transport, and storage | 0.0679 | 0.3017 | 1.1569 | 0.0425 | 0.1923 |
| 4. Banking and insurance | 0.0126 | 0.0359 | 0.0326 | 1.0424 | 0.0209 |
| 5. Public and other services | 0.0192 | 0.0494 | 0.0895 | 0.0159 | 1.0763 |

## Table 29—Leontief inverse for the India interindustry table, with import leakages, 1979/80

| Sector<br>Inverted Matrix $[I + \hat{b} - A]$ | Agriculture and Allied Industries (1) | Manufacturing and Allied Industries (2) | Trade, Transport, and Storage (3) | Banking and Insurance (4) | Public and Other Services (5) |
|---|---|---|---|---|---|
| 1. Agriculture and allied industries | 1.1445 | 0.1548 | 0.0326 | 0.0129 | 0.0838 |
| 2. Manufacturing and allied industries | 0.1531 | 1.4271 | 0.2210 | 0.1143 | 0.4151 |
| 3. Trade, transport, and storage | 0.0629 | 0.2575 | 1.1501 | 0.0389 | 0.1794 |
| 4. Banking and insurance | 0.0120 | 0.0307 | 0.0318 | 1.0420 | 0.0193 |
| 5. Public and other services | 0.0183 | 0.0421 | 0.0884 | 0.0154 | 1.0742 |

Note: $b_i = M_i/X_i$, where $M_i$ is imports by sector i and $X_i$ is output of sector i.

Thus, in Punjab, a Rs 1.00 increase in final demand from agriculture led to a direct and indirect output of only Rs 0.998 in agriculture, compared with Rs 1.11 when import leakages were neglected and output was reduced from Rs 0.22 to Rs 0.11 in manufacturing. For India also, the incremental outputs of various sectors were reduced, although to a much smaller degree.

In the case of Punjab, import leakages are even higher when final demand from manufacturing is increased. Thus a unit increase resulted in a direct and indirect output of only Rs 0.86 in manufacturing, compared with Rs 1.66 when import leakages were not taken into account. In the case of India, direct and indirect output in manufacturing decreased from Rs 1.67 to Rs 1.43 even after accounting for import leakages. Because of a very high degree of interdependence with the rest of the country, many of the gains of rapid development in Punjab are being shared with the rest of India.

It is clear that the extent of output leakages from the service sectors, namely, trade, transport and storage, banking and insurance, and public and other services, is only marginal. This again brings out the important role played by the tertiary sector in increasing domestic incomes.

Intersectoral linkages between agriculture and industry and among other sectors of the economy depend on the level of technology used in the various sectors. With modernization, most of the sectors, including agriculture, tend to use higher proportions of intermediate inputs, and this leads to greater interdependence of various sectors. Dependence of agriculture on industry, in particular, and on other sectors, in general, is bound to increase with modernization of agriculture. Similarly, because of relatively high density in the input structure of various sectors, the growth of manufacturing by itself is bound to increase interdependence among them. In short, the pattern of linkages among sectors is determined by the nature of structural changes in the production pattern. It is apparent that the extent of import leakages is quite high in the case of manufacturing in Punjab. This indicates that the scope for further development of agro-input as well as agroprocessing industries merits careful examination.

## Intersectoral Linkages—Disaggregated Analysis

This section will discuss the nature of inducement effects that are the outcome of interlinkages among all 39 producing sectors contained in the 1979/80 Punjab input-output table and the 36 sectors in the 1969/70 table. Expansion of an industry leads to a series of effects due to interlinkages. The first-order effects are felt by the direct input-supplying industries, which in turn affect the activities that supply inputs to the industries affected in the first round, and the process continues until it fades out. The degree of responsiveness depends upon the nature of the industry that is affected initially, as well as the extent to which the system of industries shows an integrated or a decomposable structure. The main point is that different industries have varied inducements in the economy, depending upon the strength of linkages.

One of the important objectives of all developing countries is to achieve rapid growth in their per capita incomes. Since high per capita income is associated with a rising share of industry in GDP, the acknowledged strategy for achieving this objective is to accelerate the process of industrialization. It is in this context that a great deal of debate has taken place about the criteria for choosing the optimal set of industries in the process of industrialization. One school of thought has argued that the extent of forward and backward linkages should constitute the most important basis for this choice. The industrialization process can be carried out in a number of ways.

The original suggestion of some authors (see, for example, Hirschman 1985) was to rank sectors by their potential stimuli for growth via the inducement mechanism and to select for promotion those key sectors that had the highest backward and forward linkages. This corresponds to what may be termed ex-ante linkage analysis and should be based on technology coefficients ($a_{ij}$) (Blumer-Thomas 1978). It is argued that the benefits of production stimuli provided by the backward and forward linkages generally represent an externality and may not be reflected in the market prices. Consequently, the social benefits of investments with high backward and forward linkages could exceed the private benefits.

Hirschman (1985) proposed developing those sectors that ranked high in terms of linkages in the developed countries. This proposal was based on the finding that there was considerable similarity in the pattern of sectoral interdependence between the developing and the advanced industrial countries (Chenery and Watanabe 1958), suggesting that there is indeed something like a fundamental structure of production (Simpson and Tsukui 1965). This approach may be applicable only if the developing countries show an interdependence pattern approximate to that found in developed countries today. For this to be so, a number of assumptions need to be made, such as (1) the commodity composition of the underdeveloped country's output has some structural resemblance to that of the country on whose input-output tables we perform the statistics; and (2) any real choice of techniques is absent.

Raj (1975) has argued that neither of these assumptions was realistic, and even with rising incomes, consumer demand in less-developed countries could fail to approximate that in developed countries because of differences in such matters as tastes, distribution of income, relative prices, and historical traditions. Thus, sectoral interdependence and the path to industrialization in developing countries are not necessarily mirrored in developed countries.

Hirschman (1985) realized that there was no guarantee that the potential stimulus measured by backward and forward linkages would be translated into actual growth; the stimulus might simply be absorbed as increased imports, higher prices, or underutilized capacity unless certain conditions were met. These conditions include the existence of a minimum market size consistent with capacity expansion, availability of complementary inputs (such as credit and skilled labor), and government policies consistent with the ranking of sectors. That sectoral linkages do not necessarily provide a stimulus to growth was brought out in a major study of linkages for several countries undertaken by Panchmukhi (1975). For example, he found that the simple correlation coefficient between the size of linkages and capacity underutilization in India was significant and positive, suggesting that in the absence of a rapid increase in their domestic demand, the expansion of sectors with high linkages may simply produce spare capacity rather than growth stimulus. In another study of Central America (Blumer-Thomas 1976), it was found that the difference between potential and actual linkages over a five-year period had not narrowed, indicating that government policy and the structure of protection were not conducive to expansion of supplying industries at the expense of imports. In such cases the only alternative would be to take policy measures that increase domestic demand for the products of these sectors.

A more fundamental set of objections to linkage analysis can be considered. Industrialization is not usually considered as an objective in itself, but as a proxy for the rise in real incomes that is supposed to accompany it. If, however, real income growth per capita is considered as the main objective, then each investment needs to be evaluated in terms of its direct and indirect effects on income rather than on output. Panchmukhi (1975) made clear that output increases do not necessarily lead to increases in income, and in fact, there is an inverse relationship between a sector's output and income multiplier effects. This suggests that the selection of key sectors by reference to their input and output linkage indices may not satisfy the income generation objective. It is also possible that the sectors with high backward linkages may have a high dependence on intermediate goods, which are typically capital-intensive. In that case, linkage analysis would suggest that priority be given to sectors that, directly or indirectly, are capital-intensive. This strategy would obviously not be suitable for developing countries with limited access to capital.

Finally, there is no consideration of efficiency or comparative costs in the selection of "key" sectors chosen with reference to linkage indices. This is particularly serious in cases where much of the potential stimulus provided by expansion of a key sector is translated into growth through a deliberate policy of import substitution. Linkage analysis does not permit a distinction between the cases where (1) the stimulus is large enough to justify establishing a supplying or using industry that is efficient; and (2) the stimulus is large enough to justify establishing a supplying or using industry that is not efficient. In the first case, government policy should ensure that the stimulus is translated into growth, while in the second, it should do so only if the subsidy needed to make the activity competitive is justified by other criteria.

Not all potential linkages can be translated into actual linkages. This suggests the need for a modified form of linkage analysis in which technological coefficients are appropriately adjusted, keeping in view the specific constraints in a country that tend to reduce the impact of growth stimuli. These constraints may be determined by considerations such as market size, efficiency, comparative costs, and natural resources and would vary from country to country. The modified inducement stimuli, as measured by the backward or forward linkage analysis, would be a better guide to the selection of key sectors.

Although there are major theoretical and methodological obstacles posed by ex-ante linkage analysis, the same is not true of ex-post analysis in which actual, currently prevailing linkages are measured. Ex-post linkage analysis requires the use of domestic coefficients rather than technological coefficients. It is well established that the ranking of sectors in terms of ex-post and ex-ante measures can differ markedly (Blumer-Thomas 1976).

Ex-post linkage analysis measures the inducement that is offered to a sector or a group of sectors if final demand changes at the margin. It can, therefore, be used for a country at a point of time to see whether government policy is consistent with the ranking of sectors. It can also be used to isolate enclave sectors and to help promote policies for the integration of the enclave with the national economy. It can be used for a country over time to establish the change in sectoral interdependence and also for a series of countries at a given time to make international comparisons (Weisskoff 1971).

Following this critical examination of the usefulness of inducement analysis, an attempt is made below to measure the backward and forward linkages of various sectors and the changes in the Punjab economy between 1969/70 and 1979/80 by using the respective input-output tables identified at the beginning of the chapter. The specific technique used is the measurement of inducement effects by Rasmussen's method of linkage analysis.

A brief outline of the Rasmussen method of estimating linkage indices is given below. Given the Leontief inverse, the backward and forward linkages are measured by

$$U_j = \frac{1}{m} Z_j \div \frac{1}{m^2} \sum_{j=1}^{m} Z_j, \quad \text{and} \tag{1}$$

$$U_i = \frac{1}{m} Z_i \div \frac{1}{m^2} \sum_{i=1}^{m} Z_i, \tag{2}$$

where

$m$ = number of industries;

$$Z_j = \sum_{i=1}^{m} Z_{ij}. \tag{3}$$

Given $Z = (I - A)^{-1}$, where

$I$ = identity matrix of n dimension, and

$$A = \text{coefficient matrix} \begin{vmatrix} a_{11} \ldots a_{1i} \ldots a_{1n} \\ \vdots \\ a_{i1} \ldots a_{ii} \ldots a_{in} \\ \vdots \\ a_{n1} \ldots a_{ni} \ldots a_{nn} \end{vmatrix},$$

$Z_{ij}$ is a typical element that shows the direct and indirect output of industry i required to meet the unit requirement of the final demand of industry j. Thus $Z_j$, the column total of the Leontief inverse, indicates the output requirements from the system of industries to cope with a unit increase in the final demand requirements of industry j.

Similarly, $Z_i$ shows the row total of the Leontief inverse and indicates the output to be supplied by industry i to cope with a unit increase in the final demand for the product of each industry. It follows from the above that

$$\sum_{j=1}^{m} Z_j = \sum_{i=1}^{m} Z_i = \sum_{i=1}^{m} \sum_{j=1}^{m} Z_{ij}. \tag{4}$$

$U_j > 1$ means that industry j is heavily dependent for its inputs on the system of industries and vice versa in the case where $U_j < 1$. Similarly, $U_i > 1$ means that industry i generally will have to increase its output more than other industries for a given increase in demand and vice versa for $U_i < 1$.

Standard deviation coefficients, $V_j$ and $V_i$, have also been computed for each of the linkage indices as suggested by Rasmussen:

$$V_j = \sqrt{\frac{1}{(m-1)} \sum_{i=1}^{m} \left[ Z_{ij} - \frac{1}{m} \sum_{i=1}^{m} Z_{ij} \right]^2 \div \frac{1}{m} \sum_{i=1}^{m} Z_{ij}}, \tag{5}$$

and

$$V_i = \sqrt{\frac{1}{(m-1)} \sum_{j=1}^{m} \left[ Z_{ij} - \frac{1}{m} \sum_{j=1}^{m} Z_{ij} \right]^2 \div \frac{1}{m} \sum_{j=1}^{m} Z_{ij}}. \tag{6}$$

$V_j$ shows the extent of disparity that industry j exhibits while drawing its inputs from the system of industries, and $V_i$ shows the extent of disparity that the system of industries displays while drawing its inputs from industry i. The smaller these indices, the more evenly distributed would be the spread effect of backward and forward linkages.

So far, only linkages based on the Z matrix have been considered, where

$$Z = (I-A)^{-1}. \tag{7}$$

These linkages, though suggestive of output expansion inducements provided by different industrial activities, may not correspond with other objectives of development such as income and employment generation. The linkage methodology, therefore, needs to be extended to capture income and employment effects. The extension procedures followed are quite straightforward. The relevant matrices are derived by weighing the output multiplier matrix by income or employment coefficients.

Consider the following equations:

$$Z = (I-A)^{-1}, \tag{8}$$

$$W = Q(I-A)^{-1}, \tag{9}$$

$$Y = V(I-A)^{-1}, \text{ and} \tag{10}$$

$$N = L(I-A)^{-1}, \tag{11}$$

where

$Z$ = output multiplier matrix,
$Q$ = diagonal matrix of sectoral wage-output ratio,
$V$ = diagonal matrix of sectoral value added-output ratio, and
$L$ = diagonal matrix of sectoral labor-output ratio.

Given W, Y, and N matrices, the $U_i$, $U_j$ and $V_i$,$V_j$ for each of the matrices can be computed.

So far, the measurement of linkage indices does not take into account the import leakages. Thus the indices given above provide an idea about the "potential" inducement effects of different industrial activities. To the extent that noncompetitive imports are exogenously determined in the input-output models, the inevitable leakages are already accounted for in the above exercises. It may be mentioned that actual linkages realized by a system of industries would differ from potential linkages where leakages due to competitive imports are taken into account. This has been done, and linkage indices have also been estimated after allowing for import leakages. A simple methodology is followed for allowing import leakages. Let us define

$$R = (I + \hat{b} - A)^{-1}, \tag{12}$$

where $\hat{b}$ = a diagonal matrix of import coefficients $m_i$, so that

$$m_i = M_i/X_i,$$

where $M_i$ is imports into the ith sector and $X_i$ is the output level of the ith sector.

It is apparent that, depending upon the propensity to import, equation (12) allows for the fact that some of the input requirements would be met through competitive imports. Given R matrix, W′, Y′, and N′ matrices can be estimated as follows:

$$W' = Q(I + \hat{b} - A)^{-1}, \tag{13}$$

$$Y' = V(I + \hat{b} - A)^{-1}, \text{ and} \tag{14}$$

$$N' = L(I + \hat{b} - A)^{-1}. \tag{15}$$

These matrices would now give employment and income effects after allowing for import leakages, and $U_i$, $U_j$ and $V_i$, $V_j$ for each of the above matrices can be similarly computed.

## Estimates of Linkage Indices

Important changes took place in the structure of the Punjab economy between 1969/70 and 1979/80, as is shown by an analysis of the forward and backward linkages among various sectors in the Punjab economy derived from the detailed 1969/70 and 1979/80 input-output tables. The estimates of various linkage indices without import leakages and with import leakages are presented along with their ranks in Appendix 1, Tables 45 and 46, for the period 1969/70 and in Tables 47 and 48 for 1979/80. The detailed results, as given in these tables, have been summarized in Tables 30 and 31.

In 1969/70 not many sectors showed both high forward and high backward linkages on account of output, income, wages, and employment, with or without import leakages.

Table 30—Linkage analysis of Punjab's economy, without import leakages, 1969/70 and 1979/80

| Linkage Effect | Z Matrix | | W Matrix | | Y Matrix | | N Matrix | |
|---|---|---|---|---|---|---|---|---|
| | 1969/70 | 1979/80 | 1969/70 | 1979/80 | 1969/70 | 1979/80 | 1969/70 | 1979/80 |
| High forward linkages $(U_i > 1)$ | 1,4,6,7, 8,16,19, 20,23,24, 34 | 1,4,7,8, 14,16,17, 18,19,20, 23,24,25, 34,36,38 | 1,3,4,5, 6,7,8,18, 23,28,29, 34,35 | 4,7,8,17, 18,19,25, 33,34,36, 37,38 | 1,2,3,4, 5,6,7,8, 20,23,28, 34 | 1,2,3,4, 5,6,7,8, 17,18,23, 33,34,36, 37,38 | 9,10,11, 12,16,17, 20,21,22, 24,34 | 1,2,3,4, 5,6,7,8, 17,18,19, 25,36,37 |
| High backward linkages $(U_j > 1)$ | 4,10,11, 12,13,14, 15,16,17, 23,24,25, 27,30,32, 33,35 | 9,10,11, 12,13,14, 15,16,17, 18,19,21, 22,23,24, 25,26,27, 28,29,30, 31,32,35 | 1,3,4,5, 6,7,8,11, 12,17,18, 23,28,29, 35 | 11,16,17, 18,19,28, 29,31,32, 33,35,36, 37,38 | 1,2,3,4, 5,6,7,8, 10,13,14, 16,17,28, 31,34 | 2,3,4,5, 6,7,8,9, 11,12,13, 14,17,18, 23,33,35, 36,37,38 | 9,10,11, 12,13,14, 16,17,20, 21,22,24, 27,30 | 2,3,4,5, 7,8,11, 12,13,16, 17,18,19, 29,32,37 |
| High backward and forward linkages $(U_i + U_j > 1)$ | 16,23,24 | 14,16,17, 18,19,23, 24,25 | 1,3,4,5, 6,7,8,18, 23,28,29, 35 | 17,18,19, 33,36,37, 38 | 1,2,3,4, 5,6,7,8, 28,34 | 2,3,4,5, 6,7,8,17, 18,23,33, 36,37,38 | 9,10,11, 12,16,17, 20,21,22, 24 | 2,3,4,5, 7,8,17, 18,19,37 |

Source: Derived from Tables 45-48, Appendix 1.

Note: Numbers correspond to sector ordering in the 1979/80 input-output table: 1. Wheat, 2. rice, 3. cotton, 4. sugarcane, 5. gram and pulses, 6. oilseeds, 7. other agriculture and forestry, 8. animal husbandry, 9. dairy products and confectionery, 10. grain mill products, 11. bakery products, 12. sugar, 13. other food industries, 14. edible oils, 15. breweries and beverages, 16. ginning and textiles, 17. sawmills and wooden goods, 18. paper, printing, and publishing, 19. rubber and leather products, 20. basic chemicals, including fertilizers, 21. drugs and pharmaceuticals, 22. other chemicals, 23. glass and mineral products, 24. basic metal industries, 25. metal products, 26. machinery, except electrical, 27. electrical machinery, 28. railroad equipment, 29. motor vehicles, manufacture and repair, 30. bicycles and parts, 31. scientific and surgical instruments, 32. sports and athletic goods, 33. miscellaneous industries, 34. electricity, gas, water supply, 35. construction, 36. trade, transport, storage, 37. other services, 38. banking and insurance, 39. real estate and ownership of dwellings.

Only the farm sectors, including animal husbandry, showed high forward and backward linkages on account of wage income and income inducements (W,Y). This was true whether or not allowance was made for import leakages. High forward and backward employment inducements were generated primarily by agroprocessing sectors both with and without import leakages. Very few sectors generated high forward and backward output inducements with or without imports.

In 1979/80 the farm sectors (sectors 1-8 in the input-output tables) continued to show high backward and forward linkages on account of income and employment inducements, with and without import leakages. This points out the important role that the agricultural sectors play in generating forward and backward income and employment linkages in Punjab.

In 1979/80, in addition to the farm sectors, many more sectors showed high forward and high backward linkages on account of output, income, wages, and employment, both without and with import leakages, than in 1969/70. This is explained by important structural changes that took place in the Punjab economy.

### Table 31—Linkage analysis of Punjab's economy, with import leakages, 1969/70 and 1979/80

| Linkage Effect | R Matrix |  | W′ Matrix |  | Y′ Matrix |  | N′ Matrix |  |
|---|---|---|---|---|---|---|---|---|
|  | 1969/70 | 1979/80 | 1969/70 | 1979/80 | 1969/70 | 1979/80 | 1969/70 | 1979/80 |
| High forward linkages ($U_i > 1$) | 1,2,4,7, 8,16,19, 23,24,25, 30 | 1,2,3,4, 8,14,16, 17,19,23, 24,25,28, 30,34,36, 37,38 | 1,2,3,4, 5,6,7,8, 16,23,29, 34,35 | 1,2,3,4, 7,8,16, 17,25,28, 29,33,34, 35,36,37, 38 | 1,2,3,4, 5,6,7,8, 28,31,34 | 1,2,3,4, 6,7,8,28, 33,34,36, 37,38,39 | 9,10,16, 17,20,24, 27,30,34 | 1,2,3,4, 5,7,8,16, 17,25,29, 36,37,38 |
| High backward linkages ($U_j > 1$) | 1,2,4,5, 8,9,10, 13,14,16, 17,19,25, 27,29,30, 32,33,35 | 1,2,3,4, 8,10,13, 14,16,17, 23,24,25, 28,29,30, 32,35,36, 37,38 | 1,3,4,5, 7,8,10, 17,28,29, 31,32,33, 35 | 2,3,4,8, 16,17,25, 28,29,30, 32,33,35, 36,37,38 | 1,2,3,4, 5,7,8,10, 17,28,31, 34,35 | 1,2,3,4, 6,7,8,10, 16,28,29, 30,32,33, 34,35,36, 37,38,39 | 9,10,13, 14,16,17, 21,22,24, 27,29,30 | 1,2,3,4, 5,7,8,10, 11,13,16, 17,25,28, 29,30,32, 36,37 |
| High backward and forward linkages ($U_i + U_j > 1$) | 1,2,4,8, 16,19,25, 30 | 1,2,3,4, 8,14,16, 17,23,24, 25,28,30, 36,37,38 | 1,3,4,5, 7,29,35 | 2,3,4,8, 16,17,25, 28,29,33, 35,36,37, 38 | 1,2,3,4, 5,7,8,28, 31,34 | 1,2,3,4, 6,7,8,28, 33,34,36, 37,38,39 | 9,10,16, 17,24,27, 30 | 1,2,3,4, 5,7,8,16, 17,25,29, 36,37 |

Source: Derived from Tables 45-48, Appendix-1.

Note: Numbers correspond to sector ordering in the 1979/80 input-output table: 1. Wheat, 2. rice, 3. cotton, 4. sugarcane, 5. gram and pulses, 6. oilseeds, 7. other agriculture and forestry, 8. animal husbandry, 9. dairy products and confectionery, 10. grain mill products, 11. bakery products, 12. sugar, 13. other food industries, 14. edible oils, 15. breweries and beverages, 16. ginning and textiles, 17. sawmills and wooden goods, 18. paper, printing, and publishing, 19. rubber and leather products, 20. basic chemicals, including fertilizers, 21. drugs and pharmaceuticals, 22. other chemicals, 23. glass and mineral products, 24. basic metal industries, 25. metal products, 26. machinery, except electrical, 27. electrical machinery, 28. railroad equipment, 29. motor vehicles, manufacture and repair, 30. bicycles and parts, 31. scientific and surgical instruments, 32. sports and athletic goods, 33. miscellaneous industries, 34. electricity, gas, water supply, 35. construction, 36. trade, transport, storage, 37. other services, 38. banking and insurance, 39. real estate and ownership of dwellings.

The sectors that emerged in 1979/80 as important, with both high backward and high forward linkages on account of output, were edible oils, furniture and fixtures, and rubber and metal products without import leakages, and edible oils, furniture and fixtures, glass, basic metals, railroad equipment, trade, other services, and banking with import leakages. On the other hand, rubber, which fell in this category in 1969/70, no longer had these linkages in 1979/80.

Furniture, paper products, glass, miscellaneous industries and trade, other services, and banking were the new sectors that showed both high forward and high backward linkages on account of income without import leakages in 1979/80, while wheat, railroad equipment, and electricity, which fell in this category in 1969/70, were no longer in that group. In 1979/80, oilseeds, miscellaneous industries, trade and transport, other services, banking, and real estate were the new sectors with high forward and backward income linkages with import leakages. Similar results are obtained by examining the wage income and employment linkages.

Regarding high forward linkages, in 1969/70, irrespective of import leakage assumptions, wheat, sugarcane, other agriculture, and animal husbandry showed high forward linkage inducements on account of output, wage income, and income. There were few nonfarm activities in 1969/70 that had high patterns of forward linkage inducements. Only the forward linkage pattern of electricity showed high output, income, and wage income inducements with or without import leakages. Similarly, when linkages both with and without import leakages were considered, only the forward linkages of basic metal industries had high employment and output inducements. In 1979/80 the farm sectors, including animal husbandry, showed high forward linkages on all four accounts, namely, output, income, wages, and employment, both with and without import leakages. Among the nonagricultural sectors, trade, transport, and storage and services showed high forward linkages on account of employment, income, and wage income, irrespective of import leakages. Similarly, sawmills, metal alloys, trade, transport, and storage, and services had high forward employment and output inducements.

Not many sectors showed high forward linkages on various counts in both 1969/70 and 1979/80. Only electricity showed high forward linkages on output, wage income, and total income inducements in both periods, irrespective of import leakages.

High backward linkages in 1969/70 were also confined to a few sectors. When import leakages were allowed, most of the agricultural sectors, namely, wheat, maize, sugarcane, other agriculture, and animal husbandry, showed high backward linkages in terms of output, income, and wages, but only two sectors, grain mill products and furniture and fixtures, showed high backward linkages on all four counts (Z, W, Y, N in Tables 30 and 31). Without import leakages, only grain mill products, edible oils, other foods, and furniture and fixtures show high output, employment, and income inducements (Z, N, Y). In 1979/80 many farm sectors showed high backward linkages without import leakages on account of income and employment. However, only three sectors, bakery products, sawmills, and printing and publishing, showed strong backward linkages on all four counts (Z, W, Y, N) without import leakages. On the other hand, in 1979/80 many sectors—rice, cotton, sugarcane, animal husbandry, textiles, railroad equipment, motor vehicles, bicycles and parts, sports goods, trade, transport, and storage, and services—showed high backward linkages on all counts (Z, W, Y, N) with import leakages.

It is obvious that with the development that has taken place, the structure of the Punjab economy has undergone some important changes. In 1979/80 many new sectors showed high backward and high forward linkages, indicating that the economy had by then started functioning at a higher technological level than it had achieved earlier. It is significant that in 1979/80 the farm and agroprocessing sectors were the ones to show a high forward and backward linkage pattern on all counts when import leakages were taken into account. This underlines the importance of agriculture and agriculture-related activities in the state.

Also in 1979/80, in addition to the farm and agroprocessing sectors, many new manufacturing sectors such as metal and nonmetallic products, machine goods, and bicycles and parts generated high forward and backward output, income, wage income, and employment linkages, indicating a relative deepening of the industrial structure of the Punjab economy. In addition, trade and transport, other services, banking, and real estate showed a high degree of forward and backward linkages on account of output, income, wages, and employment. Most of the above services were kept outside the structural matrix in 1969/70. Nevertheless, it is clear that along with the primary sector and the agroprocessing, basic metals, and machine goods sectors, the tertiary sector played an important role in generating backward and forward linkages on account of output, income, wage incomes, and employment.

# 6

# INCOME AND EMPLOYMENT MULTIPLIERS IN THE PUNJAB ECONOMY

In this chapter, input-output analysis is used to calculate direct and indirect sectoral income and employment generated in the economy as a result of increases in consumption, government expenditure, investment, or exports. This analysis can be used by planners to obtain an idea of the overall impact of their policy decisions regarding investment or other government expenditure on sectoral outputs, incomes, and employment.

The coefficient table in an input-output matrix gives the direct income and employment generated per unit of output in different sectors in the production process. However, because of interrelations among various sectors, any increase in final demand from a sector sets off a process of incremental production not only in that particular sector but also in many related sectors. This is because a unit of final demand from a sector can be satisfied only by producing, in the first instance, at least one extra unit of output in that sector. However, the production of an extra unit of output requires certain direct intermediate inputs. These inputs themselves have to be produced by the respective sectors by using inputs from various other sectors. In the same way, the second round inputs and then the third round inputs must be produced, and so on.

Whereas the direct income and employment per unit of output in a sector are dependent on degrees of capital and labor intensity in its production process, its indirect output requirements from various sectors are determined by the density of its input structure. In a developing economy, because of lack of modernization and use of limited intermediate inputs, the indirect effects are rather small, even though relatively high direct income and employment per unit of output are generated in the agricultural sectors. On the other hand, the manufacturing sectors, which are characterized by the use of relatively higher intermediate inputs, generate higher indirect output, though in their case direct income and employment per unit of output are generally relatively much lower. Thus there is no necessary correspondence between direct income and indirect income gains for various sectors.

In order to obtain a comprehensive picture, the relative contribution of any sector to the economy ought to be considered by taking into account not only the direct income and employment per unit of the sector's output but also the indirect income and employment generated by the sector in the production process. The Leontief inverse, premultiplied by the income and employment coefficients, is especially suited to capturing the total direct and indirect income and employment effect of a unit increase in final demand from any sector. The direct and indirect sectoral income and employment associated with the unit of final demand can be converted to those of a unit of output from the respective sectors to make them comparable with the direct income and employment per unit of output generated in each sector. For more meaningful comparisons between sectors, direct and indirect income and employment can be standardized and sectoral multipliers calculated by dividing the direct and indirect values by their respective direct income and employment.

It should, however, be noted that income and employment sectoral multipliers calculated by using the unadjusted Leontief inverse can be misleading, as import leakages are not taken into account. But it is possible to overcome this limitation through a modification of the Leontief inverse where import coefficients are introduced within the structural matrix. The values of indirect income and employment are considerably reduced once this adjustment is made. The higher the imports by a particular sector and the higher the import content of its various inputs, the higher the extent of reduction in the indirect income generated by it.[11] (See Appendix 3 for a discussion of the methodology.)

The above methodology does not take into account rather large interindustry effects that are generated by consumption, which is a major activity in all developing economies. As an economic activity, consumption leads to increased incomes, which in turn set in motion a chain of interindustry reactions that further increase output, income, and employment and bring about a still further increase in household consumption, and so on. It is possible to capture the induced effects of consumption through an input-output table by closing the structural matrix with respect to consumption.

In the next section an attempt is made to calculate for 1979/80 the direct and indirect income generated in each sector and the direct and indirect sectoral income multipliers per unit of output after taking into account import leakages. This is followed by a calculation of direct, indirect, and induced income effects and multipliers after including consumption in the structural matrix. Similar exercises have been done for workers employed and wage incomes. Since these multipliers were also calculated in 1969/70, any changes that took place between 1969/70 and 1979/80 in the ranking of different sectors in terms of the value of different types of multipliers are also discussed.

## Direct and Indirect Income Multipliers with Import Leakages

Because of the introduction of new technology and the use of much higher levels of intermediate inputs, the net value added per unit of output in the main agricultural sectors was considerably lower in 1979/80 than in 1969/70. Nevertheless, in both 1969/70 and 1979/80 direct income (net value added) generated per unit of output in Punjab was relatively much higher in the agricultural sectors and in animal husbandry. The range in 1979/80 was from 55.7 percent of the value of output in wheat to 83.1 percent in agriculture and forestry. On the other hand, net value added per unit of output in the industrial sectors was 8.4 percent of the value of output for grain mill products, 68.9 percent for miscellaneous industries,[12] and 43.3 percent for railroad equipment. In the electricity sector, value added constituted 57.1 percent of value of output in 1979/80 compared with 87.0 percent in 1969/70. In the tertiary sector also, value added as a proportion of value of output is quite high.

To standardize direct and indirect incomes and make them comparable, sectoral multipliers have been calculated by dividing the direct and indirect values by their respective direct income. As expected, the industrial sectors, in general, and more capital-intensive sectors with fewer direct and indirect imports, in particular, record much larger income gains than the agricultural sectors. In 1969/70, the highest values of income multipliers per unit of output were obtained in the agroprocessing industries such as grain mill products, dairying, and cotton ginning. The other sectors, which were far behind but recorded relatively large multiplier values, were sugar and confectionery, edible oils, and sawmilling. The multiplier values were relatively much smaller for other sectors than for the agroprocessing industries (Table 32).

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[11] As in Chapter 5, import coefficient $b_i$ is defined here as $M_i$ divided by $X_i$, that is, imports into ith sector divided by its output.

[12] Since the vector for miscellaneous industries has been constructed by aggregating numerous industries not included in the other sectors, the net value added of 0.6894 per unit of output in this case should be treated with due caution.

In 1979/80 also, the highest multipliers were obtained by the agroprocessing industries, with slightly different ranking. For example, while grain mill products ranks highest, it is followed by edible oils and sugar and, at some distance, by breweries and beverages. But it is noteworthy that industries such as chemicals, basic metals, drugs

### Table 32—Direct and indirect sectoral income and multipliers in Punjab, with import leakages, 1969/70

| Sector Number | Sector | Net Value Added per Unit of Output | Income Multipliers per Unit of Final Demand | Income Multipliers per Unit of Output | Indirect Income per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.777 | 1.15 | 1.11 | 0.09 |
| 2 | Rice | 0.740 | 1.14 | 1.10 | 0.08 |
| 3 | Maize | 0.751 | 1.14 | 1.13 | 0.09 |
| 4 | Cotton | 0.691 | 1.08 | 1.10 | 0.07 |
| 5 | Sugarcane | 0.674 | 1.31 | 1.18 | 0.12 |
| 6 | Gram and pulses | 0.731 | 1.15 | 1.15 | 0.11 |
| 7 | Oilseeds | 0.704 | 0.54 | 1.18 | 0.12 |
| 8 | Bajra | 0.749 | 1.19 | 1.17 | 0.13 |
| 9 | Other agriculture and forestry | 0.812 | 0.86 | 1.11 | 0.09 |
| 10 | Animal husbandry | 0.789 | 1.11 | 1.10 | 0.08 |
| 11 | Dairy products | 0.053 | 8.20 | 7.61 | 0.35 |
| 12 | Grain mill products | 0.085 | 9.56 | 9.50 | 0.72 |
| 13 | Sugar and confectionery | 0.129 | 1.65 | 3.88 | 0.37 |
| 14 | Edible oils and other food-processing industries | 0.147 | 2.53 | 2.70 | 0.25 |
| 15 | Breweries and beverages | 0.143 | 0.31 | 1.72 | 0.10 |
| 16 | Textiles | 0.244 | 1.60 | 1.15 | 0.04 |
| 17 | Cotton ginning, pressing, and other textiles | 0.047 | 6.73 | 6.90 | 0.28 |
| 18 | Sawmills and wooden containers | 0.274 | 2.52 | 2.48 | 0.41 |
| 19 | Furniture and fixtures | 0.338 | 1.80 | 1.79 | 0.27 |
| 20 | Printing and publishing | 0.366 | 0.68 | 1.17 | 0.06 |
| 21 | Rubber and leather products | 0.285 | 1.20 | 1.23 | 0.07 |
| 22 | Basic chemicals, including fertilzers | 0.412 | 0.92 | 1.40 | 0.17 |
| 23 | Other chemicals | 0.194 | 0.47 | 1.45 | 0.09 |
| 24 | Glass and mineral products | 0.269 | 1.13 | 1.04 | 0.01 |
| 25 | Basic metal industries | 0.132 | 0.79 | 1.11 | 0.02 |
| 26 | Metal products | 0.272 | 1.19 | 1.17 | 0.05 |
| 27 | Machinery, except electrical | 0.302 | 0.88 | 1.15 | 0.05 |
| 28 | Electrical machinery | 0.198 | 1.23 | 1.37 | 0.07 |
| 29 | Railroad equipment | 0.713 | 1.04 | 1.04 | 0.03 |
| 30 | Transport equipment | 0.308 | 1.04 | 1.02 | 0.06 |
| 31 | Repair of transport equipment | 0.403 | 1.58 | 1.58 | 0.23 |
| 32 | Motorcycles and bicycles | 0.251 | 1.42 | 1.20 | 0.05 |
| 33 | Scientific and surgical instruments | 0.615 | 1.04 | 1.04 | 0.02 |
| 34 | Miscellaneous industries | 0.276 | 1.56 | 1.57 | 0.16 |
| 35 | Construction | 0.394 | 1.34 | 1.34 | 0.13 |
| 36 | Electricity | 0.871 | 1.05 | 1.00 | 0.00 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

and pharmaceuticals, sports goods, and construction have also become important and have recorded a high value of multipliers. In terms of indirect income, though agroprocessing industries generate the highest income, the contribution of other industries and sectors such as other chemicals, construction, sports goods, and drugs and pharmaceuticals is also quite high (Table 33).

**Table 33—Direct and indirect sectoral income and multipliers in Punjab, with import leakages, 1979/80**

| Sector Number | Sector | Net Value Added per Unit of Output | Income Multipliers per Unit of Final Demand | Income Multipliers per Unit of Output | Indirect Income per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.557 | 1.18 | 1.14 | 0.08 |
| 2 | Rice | 0.689 | 1.07 | 1.08 | 0.06 |
| 3 | Cotton | 0.716 | 0.99 | 1.09 | 0.06 |
| 4 | Sugarcane | 0.799 | 1.05 | 1.06 | 0.05 |
| 5 | Gram and pulses | 0.762 | 0.57 | 1.07 | 0.05 |
| 6 | Oilseeds | 0.808 | 0.65 | 1.07 | 0.06 |
| 7 | Other agriculture and forestry | 0.831 | 0.73 | 1.02 | 0.02 |
| 8 | Animal husbandry | 0.702 | 1.20 | 1.22 | 0.16 |
| 9 | Dairy products and confectionery | 0.231 | 1.18 | 2.71 | 0.40 |
| 10 | Grain mill products | 0.084 | 6.14 | 7.74 | 0.56 |
| 11 | Bakery products | 0.340 | 0.97 | 1.91 | 0.31 |
| 12 | Sugar | 0.175 | 1.10 | 4.33 | 0.58 |
| 13 | Other food industries | 0.274 | 1.62 | 2.48 | 0.41 |
| 14 | Edible oils | 0.075 | 4.23 | 4.52 | 0.26 |
| 15 | Breweries and beverages | 0.166 | 1.71 | 2.78 | 0.30 |
| 16 | Ginning and textiles | 0.181 | 2.68 | 1.80 | 0.14 |
| 17 | Sawmills and wooden goods | 0.389 | 1.11 | 1.27 | 0.10 |
| 18 | Paper, printing, and publishing | 0.353 | 0.27 | 1.35 | 0.13 |
| 19 | Rubber and leather products | 0.262 | 1.10 | 1.59 | 0.16 |
| 20 | Basic chemicals, including fertilizers | 0.249 | 0.53 | 1.46 | 0.11 |
| 21 | Drugs and pharmaceuticals | 0.171 | 0.05 | 2.32 | 0.23 |
| 22 | Other chemicals | 0.154 | 0.13 | 2.78 | 0.28 |
| 23 | Glass and mineral products | 0.377 | 1.19 | 1.23 | 0.09 |
| 24 | Basic metal industries | 0.091 | 2.00 | 2.59 | 0.14 |
| 25 | Metal products | 0.203 | 1.87 | 1.81 | 0.16 |
| 26 | Machinery, except electrical | 0.215 | 0.88 | 1.82 | 0.18 |
| 27 | Electrical machinery | 0.210 | 0.92 | 1.86 | 0.18 |
| 28 | Railroad equipment | 0.433 | 1.41 | 1.32 | 0.14 |
| 29 | Motor vehicles, manufacture and repair | 0.372 | 1.28 | 1.39 | 0.14 |
| 30 | Bicycles and parts | 0.314 | 1.65 | 1.63 | 0.20 |
| 31 | Scientific and surgical instruments | 0.288 | 0.37 | 1.58 | 0.17 |
| 32 | Sports and athletic goods | 0.247 | 1.97 | 1.99 | 0.24 |
| 33 | Miscellaneous industries | 0.689 | 0.79 | 1.13 | 0.09 |
| 34 | Electricity, gas, and water supply | 0.571 | 0.92 | 1.03 | 0.02 |
| 35 | Construction | 0.349 | 2.04 | 2.04 | 0.36 |
| 36 | Trade, transport, and storage | 0.625 | 1.29 | 1.14 | 0.09 |
| 37 | Other services | 0.537 | 1.37 | 1.28 | 0.15 |
| 38 | Banking and insurance | 0.824 | 1.14 | 1.05 | 0.04 |
| 39 | Real estate and ownership of dwellings | 0.655 | 1.01 | 1.01 | 0.00 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

## Direct, Indirect, and Induced Income Multipliers

As noted earlier, the introduction of consumption in the structural matrix captures the induced effects of consumption activity along with that of indirect income. The results indicate that the built-in consumption-induced effects bring about substantially higher values for direct, indirect, and induced income and their multipliers. In 1969/70 the ranking of various sectors in terms of direct, indirect, and induced income multipliers per unit of output was grain mill products, dairy products, cotton ginning, sugar, edible oils, and sawmills (Table 34).

**Table 34—Direct, indirect, and induced sectoral income and multipliers in Punjab, with import leakages, 1969/70**

| Sector Number | Sector | Net Value Added per Unit of Output | Income Multipliers per Unit of Final Demand | Income Multipliers per Unit of Output | Indirect and Induced Income per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.777 | 2.13 | 1.62 | 0.48 |
| 2 | Rice | 0.740 | 2.13 | 2.03 | 0.76 |
| 3 | Maize | 0.751 | 2.13 | 2.04 | 0.78 |
| 4 | Cotton | 0.691 | 2.00 | 2.04 | 0.72 |
| 5 | Sugarcane | 0.674 | 2.43 | 2.13 | 0.76 |
| 6 | Gram and pulses | 0.731 | 2.15 | 2.09 | 0.80 |
| 7 | Oilseeds | 0.704 | 1.00 | 2.17 | 0.82 |
| 8 | Bajra | 0.749 | 2.21 | 2.18 | 0.88 |
| 9 | Other agriculture and forestry | 0.812 | 1.60 | 1.87 | 0.71 |
| 10 | Animal husbandry | 0.789 | 2.06 | 1.48 | 0.38 |
| 11 | Dairy products | 0.053 | 15.25 | 14.15 | 0.70 |
| 12 | Grain mill products | 0.085 | 17.78 | 16.56 | 1.33 |
| 13 | Sugar and confectionery | 0.129 | 3.06 | 7.16 | 0.80 |
| 14 | Edible oils and other food-processing industries | 0.147 | 4.70 | 4.95 | 0.59 |
| 15 | Breweries and beverages | 0.143 | 0.58 | 3.19 | 0.31 |
| 16 | Textiles | 0.244 | 2.98 | 2.07 | 0.26 |
| 17 | Cotton ginning, pressing, and other textiles | 0.047 | 12.52 | 12.73 | 0.56 |
| 18 | Sawmills and wooden containers | 0.274 | 4.69 | 4.61 | 0.99 |
| 19 | Furniture and fixtures | 0.338 | 3.35 | 3.34 | 0.79 |
| 20 | Printing and publishing | 0.366 | 1.27 | 2.17 | 0.43 |
| 21 | Rubber and leather products | 0.285 | 2.23 | 2.27 | 0.36 |
| 22 | Basic chemicals, including fertilizers | 0.412 | 1.71 | 2.58 | 0.65 |
| 23 | Other chemicals | 0.194 | 0.87 | 2.68 | 0.33 |
| 24 | Glass and mineral products | 0.269 | 2.09 | 1.92 | 0.25 |
| 25 | Basic metal industries | 0.132 | 1.47 | 2.07 | 0.14 |
| 26 | Metal products | 0.272 | 2.21 | 2.18 | 0.32 |
| 27 | Machinery, except electrical | 0.302 | 1.63 | 2.15 | 0.35 |
| 28 | Electrical machinery | 0.198 | 2.30 | 2.54 | 0.31 |
| 29 | Railroad equipment | 0.713 | 1.93 | 1.93 | 0.67 |
| 30 | Transport equipment | 0.308 | 1.14 | 1.12 | 0.37 |
| 31 | Repair of transport equipment | 0.403 | 2.53 | 2.53 | 0.62 |
| 32 | Motorcycles and bicycles | 0.251 | 2.64 | 2.22 | 0.31 |
| 33 | Scientific and surgical instruments | 0.615 | 1.94 | 1.93 | 0.57 |
| 34 | Miscellaneous industries | 0.276 | 2.91 | 2.91 | 0.53 |
| 35 | Construction | 0.394 | 2.49 | 2.49 | 0.59 |
| 36 | Electricity | 0.871 | 1.95 | 1.84 | 0.73 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

The agroprocessing industries again recorded the highest value of multipliers in 1979/80, with grain mill products ranking first, then edible oils, sugar, and breweries and beverages. Other agroprocessing industries that had a high value of multipliers are other foods, dairy products, and cotton ginning and textiles. However, as in the case of direct and indirect income multipliers, other chemicals, drugs and pharmaceuticals, basic metals, sports goods, electrical and nonelectrical machinery, bicycles, surgical instruments, and construction also ranked fairly high in direct, indirect, and induced income multipliers (Table 35).

**Table 35—Direct, indirect, and induced sectoral income and multipliers in Punjab, with import leakages, 1979/80**

| Sector Number | Sector | Net Value Added per Unit of Output | Income Multipliers per Unit of Final Demand | Income Multipliers per Unit of Output | Indirect and Induced Income per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.557 | 1.90 | 1.71 | 0.39 |
| 2 | Rice | 0.689 | 1.73 | 1.72 | 0.50 |
| 3 | Cotton | 0.716 | 1.60 | 1.74 | 0.53 |
| 4 | Sugarcane | 0.799 | 1.70 | 1.69 | 0.55 |
| 5 | Gram and pulses | 0.762 | 0.93 | 1.70 | 0.54 |
| 6 | Oilseeds | 0.808 | 1.05 | 1.72 | 0.59 |
| 7 | Other agriculture and forestry | 0.831 | 1.18 | 1.54 | 0.44 |
| 8 | Animal husbandry | 0.702 | 1.94 | 1.71 | 0.50 |
| 9 | Dairy products and confectionery | 0.231 | 1.50 | 4.33 | 0.77 |
| 10 | Grain mill products | 0.084 | 9.93 | 12.02 | 0.92 |
| 11 | Bakery products | 0.340 | 1.56 | 3.08 | 0.71 |
| 12 | Sugar | 0.175 | 1.77 | 6.97 | 1.04 |
| 13 | Other food industries | 0.274 | 2.62 | 3.98 | 0.82 |
| 14 | Edible oils | 0.075 | 6.84 | 7.21 | 0.46 |
| 15 | Breweries and beverages | 0.166 | 2.76 | 4.47 | 0.58 |
| 16 | Ginning and textiles | 0.181 | 4.33 | 2.79 | 0.32 |
| 17 | Sawmills and wooden goods | 0.389 | 1.80 | 2.05 | 0.41 |
| 18 | Paper, printing, and publishing | 0.353 | 0.44 | 2.19 | 0.42 |
| 19 | Rubber and leather products | 0.262 | 1.78 | 2.56 | 0.41 |
| 20 | Basic chemicals, including fertilizers | 0.249 | 0.86 | 2.35 | 0.34 |
| 21 | Drugs and pharmaceuticals | 0.171 | 0.08 | 3.75 | 0.47 |
| 22 | Other chemicals | 0.154 | 0.21 | 4.49 | 0.54 |
| 23 | Glass and mineral products | 0.377 | 1.92 | 1 99 | 0.37 |
| 24 | Basic metal industries | 0.091 | 3.23 | 4.18 | 0.29 |
| 25 | Metal products | 0.203 | 3.03 | 2.91 | 0.39 |
| 26 | Machinery, except electrical | 0.215 | 1.42 | 2.94 | 0.42 |
| 27 | Electrical machinery | 0.210 | 1.49 | 3.00 | 0.42 |
| 28 | Railroad equipment | 0.433 | 2.28 | 2.13 | 0.49 |
| 29 | Motor vehicles, manufacture and repair | 0.372 | 2.07 | 2.24 | 0.46 |
| 30 | Bicycles and parts | 0.314 | 2.67 | 2.63 | 0.51 |
| 31 | Scientific and surgical instruments | 0.288 | 0.60 | 2.55 | 0.45 |
| 32 | Sports and athletic goods | 0.247 | 3.19 | 3.21 | 0.55 |
| 33 | Miscellaneous industries | 0.689 | 1.27 | 1.83 | 0.57 |
| 34 | Electricity, gas, and water supply | 0.571 | 1.50 | 1.64 | 0.36 |
| 35 | Construction | 0.349 | 3.30 | 3.30 | 0.81 |
| 36 | Trade, transport, and storage | 0.625 | 2.09 | 1.59 | 0.37 |
| 37 | Other services | 0.537 | 2.21 | 2.00 | 0.54 |
| 38 | Banking and insurance | 0.824 | 1.84 | 1.67 | 0.55 |
| 39 | Real estate and ownership of dwellings | 0.655 | 1.63 | 1.60 | 0.39 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

In 1969/70 it was discovered that induced income gains were unevenly distributed among the various sectors, and substantial induced income gains were recorded only by those sectors that were relatively more important in the consumption basket. These were grain mill products, sawmills, ginning, *bajra,* and oilseeds.

The consumption-oriented sectors also showed high indirect and induced income gains in 1979/80. The ranking of various sectors in terms of induced income gains was sugar, grain mill products, other food industries, dairy products, and bakery products. Induced income gains in construction were also quite high and considerable induced incomes were generated by trade and transport, other services, banking and insurance, and real estate.

## Direct and Indirect Employment Multipliers

In 1969/70 direct employment in terms of both workers and person-hours was highest in the agricultural sectors, ranging from 0.135 workers per Rs 1,000 of output in rice to 0.571 workers in cotton. In the industrial sectors, the employment intensity was much lower and ranged from 0.006 workers per Rs 1,000 of output in dairy products to 0.157 workers in printing and publishing (Table 36).

In 1979/80 also, the highest direct employment was generated in the agricultural sectors, although its intensity was relatively much lower, varying between 0.055 workers per Rs 1,000 of output in oilseeds to 0.108 workers in rice. The manufacturing sectors again recorded a much lower employment intensity, ranging from 0.007 workers per Rs 1,000 of output in edible oils to 0.076 workers in printing and publishing. As expected, services are highly labor-intensive (Table 37).

In 1969/70 the highest values of employment multipliers per unit of output were in the agroprocessing industries such as dairy products, followed by grain mill products, cotton ginning, sugar and confectionery, edible oils, and sawmills.

The agroprocessing industries also generated the highest employment multipliers in 1979/80, although the ranking was slightly different. The first position in terms of employment multipliers was once again occupied by dairy products, followed by grain mill products, edible oils, breweries, and sugar. Besides the agroprocessing industries, other sectors that had high employment multipliers were construction, basic metals, basic chemicals, and other chemicals.

## Direct, Indirect, and Induced Employment Multipliers

The introduction of consumption into the structural matrix resulted in a significant increase in the value of multipliers, particularly in sectors that are important in the consumption basket. In 1969/70 dairy products ranked highest in terms of direct, indirect, and induced employment multipliers, followed by grain mill products, basic chemicals, cotton ginning, sugar, edible oils, sawmills, other chemicals, and electrical machinery (Table 38).

In 1979/80 dairy products again recorded the highest rank in terms of the direct, indirect, and induced employment multipliers. Next came miscellaneous industries, grain mill products, basic chemicals, breweries, edible oils, and construction. The ranking in terms of indirect- and induced-employment gains is also similar to that of 1969/70 (Table 39).

### Table 36—Direct and indirect sectoral employment and multipliers in Punjab, with import leakages, 1969/70

| Sector Number | Sector | Workers per 1,000 Units of Output | Employment Multipliers per Unit of Final Demand | Employment Multipliers per Unit of Output | Indirect Employment per Unit of Output |
|---|---|---|---|---|---|
| | | (persons/ Rs 1,000) | | | (persons/ Rs 1,000) |
| 1 | Wheat | 0.146 | 1.16 | 1.13 | 0.02 |
| 2 | Rice | 0.135 | 1.15 | 1.11 | 0.01 |
| 3 | Maize | 0.214 | 1.12 | 1.10 | 0.02 |
| 4 | Cotton | 0.571 | 1.01 | 1.03 | 0.02 |
| 5 | Sugarcane | 0.317 | 1.21 | 1.10 | 0.03 |
| 6 | Gram and pulses | 0.181 | 1.16 | 1.16 | 0.03 |
| 7 | Oilseeds | 0.289 | 0.50 | 1.10 | 0.03 |
| 8 | Bajra | 0.284 | 1.13 | 1.12 | 0.03 |
| 9 | Other agriculture and forestry | 0.303 | 0.83 | 1.07 | 0.02 |
| 10 | Animal husbandry | 0.205 | 1.13 | 1.13 | 0.03 |
| 11 | Dairy products | 0.006 | 16.93 | 15.72 | 0.10 |
| 12 | Grain mill products | 0.014 | 12.10 | 12.02 | 0.15 |
| 13 | Sugar and confectionery | 0.043 | 2.02 | 4.75 | 0.16 |
| 14 | Edible oils and other food-processing industries | 0.041 | 3.03 | 3.23 | 0.09 |
| 15 | Breweries and beverages | 0.076 | 0.28 | 1.51 | 0.04 |
| 16 | Textiles | 0.068 | 1.57 | 1.13 | 0.01 |
| 17 | Cotton ginning, pressing, and other textiles | 0.019 | 6.43 | 6.60 | 0.11 |
| 18 | Sawmills and wooden containers | 0.076 | 2.94 | 2.88 | 0.14 |
| 19 | Furniture and fixtures | 0.120 | 1.78 | 1.77 | 0.09 |
| 20 | Printing and publishing | 0.157 | 0.60 | 1.03 | 0.01 |
| 21 | Rubber and leather products | 0.120 | 1.07 | 1.09 | 0.01 |
| 22 | Basic chemicals, including fertilizers | 0.013 | 1.35 | 2.06 | 0.01 |
| 23 | Other chemicals | 0.029 | 0.44 | 1.37 | 0.01 |
| 24 | Glass and mineral products | 0.123 | 1.09 | 1.01 | 0.00 |
| 25 | Basic metal industries | 0.029 | 0.74 | 1.04 | 0.00 |
| 26 | Metal products | 0.089 | 1.10 | 1.09 | 0.01 |
| 27 | Machinery, except electrical | 0.066 | 0.88 | 1.15 | 0.01 |
| 28 | Electrical machinery | 0.037 | 1.29 | 1.42 | 0.02 |
| 29 | Railroad equipment | 0.107 | 1.03 | 1.03 | 0.00 |
| 30 | Transport equipment | 0.050 | 1.32 | 1.30 | 0.02 |
| 31 | Repair of transport equipment | 0.136 | 1.06 | 1.06 | 0.01 |
| 32 | Motorcycles and bicycles | 0.041 | 1.52 | 1.28 | 0.01 |
| 33 | Scientific and surgical instruments | 0.130 | 1.06 | 1.05 | 0.01 |
| 34 | Miscellaneous industries | 0.091 | 1.50 | 1.50 | 0.05 |
| 35 | Construction | 0.121 | 1.44 | 1.44 | 0.05 |
| 36 | Electricity | 0.054 | 1.05 | 1.00 | 0.00 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

## Direct and Indirect Wage Income and Multipliers

As noted earlier, the service sectors had not been included in the 1969/70 input-output table. Of the included sectors, most of the agricultural sectors had a relatively higher direct wage income per unit of output than the manufacturing sectors. On the other hand, the highest indirect wage income gains were in the industrial sectors, in general, and the agriculture-based industries, in particular. In terms of indirect wage accrual, the highest wage income gains were recorded by agroprocessing industries such as sugar and confectionery, grain mill products, sawmills, cotton ginning, dairying,

## Table 37—Direct and indirect sectoral employment and multipliers in Punjab, with import leakages, 1979/80

| Sector Number | Sector | Workers per 1,000 Units of Output | Employment Multipliers per Unit of Final Demand | Employment Multipliers per Unit of Output | Indirect Employment per Unit of Output |
|---|---|---|---|---|---|
| | | (persons/ Rs 1,000) | | | (persons/ Rs 1,000) |
| 1 | Wheat | 0.056 | 1.14 | 1.11 | 0.01 |
| 2 | Rice | 0.108 | 1.02 | 1.04 | 0.00 |
| 3 | Cotton | 0.102 | 0.96 | 1.06 | 0.01 |
| 4 | Sugarcane | 0.086 | 1.05 | 1.06 | 0.01 |
| 5 | Gram and pulses | 0.104 | 0.57 | 1.06 | 0.01 |
| 6 | Oilseeds | 0.055 | 0.68 | 1.13 | 0.01 |
| 7 | Other agriculture and forestry | 0.104 | 0.73 | 1.02 | 0.00 |
| 8 | Animal husbandry | 0.104 | 1.15 | 1.17 | 0.02 |
| 9 | Dairy products and confectionery | 0.008 | 3.26 | 7.51 | 0.05 |
| 10 | Grain mill products | 0.013 | 4.16 | 5.25 | 0.05 |
| 11 | Bakery products | 0.073 | 0.73 | 1.43 | 0.03 |
| 12 | Sugar | 0.023 | 0.91 | 3.61 | 0.06 |
| 13 | Other food industries | 0.033 | 1.55 | 2.38 | 0.05 |
| 14 | Edible oils | 0.007 | 3.56 | 3.81 | 0.02 |
| 15 | Breweries and beverages | 0.009 | 2.25 | 3.65 | 0.02 |
| 16 | Ginning and textiles | 0.024 | 2.52 | 1.69 | 0.02 |
| 17 | Sawmills and wooden goods | 0.076 | 0.99 | 1.12 | 0.01 |
| 18 | Paper, printing, and publishing | 0.076 | 0.23 | 1.16 | 0.01 |
| 19 | Rubber and leather products | 0.043 | 0.95 | 1.37 | 0.02 |
| 20 | Basic chemicals, including fertilizers | 0.005 | 0.88 | 2.43 | 0.01 |
| 21 | Drugs and pharmaceuticals | 0.026 | 0.04 | 1.75 | 0.02 |
| 22 | Other chemicals | 0.021 | 0.11 | 2.25 | 0.03 |
| 23 | Glass and mineral products | 0.029 | 1.18 | 1.22 | 0.01 |
| 24 | Basic metal industries | 0.009 | 1.96 | 2.54 | 0.01 |
| 25 | Metal products | 0.038 | 1.38 | 1.33 | 0.01 |
| 26 | Machinery, except electrical | 0.024 | 0.79 | 1.64 | 0.02 |
| 27 | Electrical machinery | 0.015 | 1.00 | 2.02 | 0.02 |
| 28 | Railroad equipment | 0.036 | 1.44 | 1.35 | 0.01 |
| 29 | Motor vehicles, manufacture and repair | 0.066 | 1.08 | 1.18 | 0.01 |
| 30 | Bicycles and parts | 0.028 | 1.71 | 1.68 | 0.02 |
| 31 | Scientific and surgical instruments | 0.040 | 0.32 | 1.35 | 0.01 |
| 32 | Sports and athletic goods | 0.043 | 1.64 | 1.65 | 0.03 |
| 33 | Miscellaneous industries | 0.008 | 1.56 | 2.25 | 0.01 |
| 34 | Electricity, gas, and water supply | 0.026 | 0.93 | 1.04 | 0.00 |
| 35 | Construction | 0.015 | 2.96 | 2.96 | 0.03 |
| 36 | Trade, transport, and storage | 0.040 | 1.45 | 1.28 | 0.01 |
| 37 | Other services | 0.094 | 1.21 | 1.13 | 0.01 |
| 38 | Banking and insurance | 0.036 | 1.21 | 1.11 | 0.00 |
| 39 | Real estate and ownership of dwellings | 0.031 | 1.02 | 1.02 | 0.01 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

and edible oils, in that order. The value of wage income multipliers was also the highest for dairy products, followed by grain mill products, cotton ginning, sugar, and edible oils (Table 40).

In 1979/80 the highest direct wage income per unit of output was found in the tertiary sector. This was followed by construction, a few manufacturing sectors, and most of the agricultural sectors. With a few exceptions, compared with the agricultural sectors, most of the manufacturing sectors had a lower direct wage income per unit of output. On the other hand, as in 1969/70, it is the manufacturing sectors that

## Table 38—Direct, indirect, and induced sectoral employment and multipliers in Punjab, with import leakages, 1969/70

| Sector Number | Sector | Workers per 1,000 Units of Output | Employment Multipliers per Unit of Final Demand | Employment Multipliers per Unit of Output | Indirect and Induced Employment per 1,000 Units of Output |
|---|---|---|---|---|---|
| | | (persons/ Rs 1,000) | | | (persons/ Rs 1,000) |
| 1 | Wheat | 0.146 | 2.50 | 1.91 | 0.13 |
| 2 | Rice | 0.135 | 2.53 | 2.41 | 0.19 |
| 3 | Maize | 0.214 | 2.00 | 1.92 | 0.20 |
| 4 | Cotton | 0.571 | 1.29 | 1.32 | 0.18 |
| 5 | Sugarcane | 0.317 | 1.83 | 1.60 | 0.19 |
| 6 | Gram and pulses | 0.181 | 2.19 | 2.14 | 0.21 |
| 7 | Oilseeds | 0.289 | 0.79 | 1.72 | 0.21 |
| 8 | Bajra | 0.284 | 1.82 | 1.80 | 0.23 |
| 9 | Other agriculture and forestry | 0.303 | 1.34 | 1.57 | 0.17 |
| 10 | Animal husbandry | 0.205 | 2.07 | 1.49 | 0.10 |
| 11 | Dairy products | 0.006 | 31.78 | 29.50 | 0.18 |
| 12 | Grain mill products | 0.014 | 25.21 | 23.49 | 0.31 |
| 13 | Sugar and confectionery | 0.043 | 3.13 | 7.31 | 0.27 |
| 14 | Edible oils and other food-processing industries | 0.041 | 5.04 | 5.30 | 0.18 |
| 15 | Breweries and beverages | 0.076 | 0.41 | 2.22 | 0.09 |
| 16 | Textiles | 0.068 | 2.83 | 1.97 | 0.07 |
| 17 | Cotton ginning, pressing, and other textiles | 0.019 | 10.14 | 10.32 | 0.18 |
| 18 | Sawmills and wooden containers | 0.076 | 4.94 | 4.85 | 0.29 |
| 19 | Furniture and fixtures | 0.120 | 2.90 | 2.89 | 0.23 |
| 20 | Printing and publishing | 0.157 | 0.96 | 1.63 | 0.10 |
| 21 | Rubber and leather products | 0.120 | 1.70 | 1.73 | 0.09 |
| 22 | Basic chemicals, including fertilizers | 0.013 | 7.75 | 11.70 | 0.14 |
| 23 | Other chemicals | 0.029 | 1.14 | 3.50 | 0.07 |
| 24 | Glass and mineral products | 0.123 | 1.64 | 1.50 | 0.06 |
| 25 | Basic metal industries | 0.029 | 1.55 | 2.18 | 0.03 |
| 26 | Metal products | 0.089 | 1.90 | 1.88 | 0.08 |
| 27 | Machinery, except electrical | 0.066 | 1.77 | 2.33 | 0.09 |
| 28 | Electrical machinery | 0.037 | 2.73 | 3.02 | 0.08 |
| 29 | Railroad equipment | 0.107 | 2.56 | 2.56 | 0.17 |
| 30 | Transport equipment | 0.050 | 2.95 | 2.90 | 0.10 |
| 31 | Repair of transport equipment | 0.136 | 1.79 | 1.79 | 0.11 |
| 32 | Motorcycles and bicycles | 0.041 | 3.43 | 2.88 | 0.08 |
| 33 | Scientific and surgical instruments | 0.130 | 2.15 | 2.14 | 0.15 |
| 34 | Miscellaneous industries | 0.091 | 2.54 | 2.53 | 0.14 |
| 35 | Construction | 0.121 | 2.41 | 2.41 | 0.17 |
| 36 | Electricity | 0.054 | 4.79 | 4.51 | 0.19 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

recorded relatively much higher indirect wage income gains. Within the manufacturing sector the highest wage income gains were in grain mill products, followed by dairy products, sugar, other foods, and breweries.

Another sector that had high wage income gains is construction. In terms of the value of wage income multipliers, the ranking is breweries, dairy products, grain mill products, and edible oils among the agroprocessing industries, and basic metals, sugar, electrical machinery, other chemicals, other food industries, bicycles, and drugs and pharmaceuticals (Table 41).

## Table 39—Direct, indirect, and induced sectoral employment and multipliers in Punjab, with import leakages, 1979/80

| Sector Number | Sector | Workers per 1,000 Units of Output | Employment Multipliers per Unit of Final Demand | Employment Multipliers per Unit of Output | Indirect and Induced Employment per 1,000 Units of Output |
|---|---|---|---|---|---|
| | | (persons/ Rs 1,000) | | | (persons/ Rs 1,000) |
| 1 | Wheat | 0.056 | 1.92 | 1.72 | 0.04 |
| 2 | Rice | 0.108 | 1.48 | 1.48 | 0.05 |
| 3 | Cotton | 0.102 | 1.42 | 1.55 | 0.06 |
| 4 | Sugarcane | 0.086 | 1.70 | 1.69 | 0.06 |
| 5 | Gram and pulses | 0.104 | 0.85 | 1.57 | 0.06 |
| 6 | Oilseeds | 0.055 | 1.32 | 2.17 | 0.06 |
| 7 | Other agriculture and forestry | 0.104 | 1.11 | 1.45 | 0.05 |
| 8 | Animal husbandry | 0.104 | 1.69 | 1.49 | 0.05 |
| 9 | Dairy products and confectionery | 0.008 | 5.60 | 12.76 | 0.09 |
| 10 | Grain mill products | 0.013 | 6.85 | 8.29 | 0.09 |
| 11 | Bakery products | 0.073 | 1.03 | 2.02 | 0.07 |
| 12 | Sugar | 0.023 | 1.46 | 5.75 | 0.11 |
| 13 | Other food industries | 0.033 | 2.44 | 3.72 | 0.09 |
| 14 | Edible oils | 0.007 | 6.41 | 6.75 | 0.04 |
| 15 | Breweries and beverages | 0.009 | 4.42 | 7.14 | 0.05 |
| 16 | Ginning and textiles | 0.024 | 3.84 | 2.47 | 0.04 |
| 17 | Sawmills and wooden goods | 0.076 | 1.37 | 1.55 | 0.04 |
| 18 | Paper, printing, and publishing | 0.076 | 0.32 | 1.57 | 0.04 |
| 19 | Rubber and leather products | 0.043 | 1.40 | 2.01 | 0.04 |
| 20 | Basic chemicals, including fertilizers | 0.005 | 2.81 | 7.70 | 0.03 |
| 21 | Drugs and pharmaceuticals | 0.026 | 0.06 | 2.75 | 0.05 |
| 22 | Other chemicals | 0.021 | 0.17 | 3.62 | 0.05 |
| 23 | Glass and mineral products | 0.029 | 2.21 | 2.30 | 0.04 |
| 24 | Basic metal industries | 0.009 | 3.37 | 4.36 | 0.03 |
| 25 | Metal products | 0.038 | 2.05 | 1.97 | 0.04 |
| 26 | Machinery, except electrical | 0.024 | 1.32 | 2.73 | 0.04 |
| 27 | Electrical machinery | 0.015 | 1.85 | 3.74 | 0.04 |
| 28 | Railroad equipment | 0.036 | 2.56 | 2.40 | 0.05 |
| 29 | Motor vehicles, manufacture and repair | 0.066 | 1.56 | 1.70 | 0.05 |
| 30 | Bicycles and parts | 0.028 | 2.93 | 2.89 | 0.05 |
| 31 | Scientific and surgical instruments | 0.040 | 0.50 | 2.11 | 0.04 |
| 32 | Sports and athletic goods | 0.043 | 2.40 | 2.42 | 0.06 |
| 33 | Miscellaneous industries | 0.008 | 5.85 | 8.40 | 0.06 |
| 34 | Electricity, gas, and water supply | 0.026 | 2.30 | 2.52 | 0.04 |
| 35 | Construction | 0.015 | 6.20 | 6.20 | 0.08 |
| 36 | Trade, transport, and storage | 0.040 | 2.82 | 2.14 | 0.05 |
| 37 | Other services | 0.094 | 1.73 | 1.56 | 0.05 |
| 38 | Banking and insurance | 0.036 | 2.97 | 2.69 | 0.06 |
| 39 | Real estate and ownership of dwellings | 0.031 | 2.42 | 2.37 | 0.04 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

## Direct, Indirect, and Induced Wage Income and Multipliers

With the introduction of consumption into the structural matrix, the direct, indirect, and induced wage income multipliers recorded very high values, particularly for many of the agroprocessing industries, which are consumption-oriented. In 1969/70, the highest values for direct, indirect, and induced wage income multipliers were for grain

## Table 40—Direct and indirect sectoral wage incomes and multipliers in Punjab, with import leakages, 1969/70

| Sector Number | Sector | Wages per Unit of Output | Wage Multipliers per Unit of Final Demand | Wage Multipliers per Unit of Output | Indirect Wages per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.217 | 1.16 | 1.13 | 0.02 |
| 2 | Rice | 0.265 | 1.15 | 1.11 | 0.01 |
| 3 | Maize | 0.299 | 1.12 | 1.10 | 0.02 |
| 4 | Cotton | 0.266 | 1.01 | 1.03 | 0.02 |
| 5 | Sugarcane | 0.289 | 1.21 | 1.10 | 0.03 |
| 6 | Gram and pulses | 0.213 | 1.16 | 1.16 | 0.03 |
| 7 | Oilseeds | 0.213 | 0.50 | 1.10 | 0.03 |
| 8 | Bajra | 0.208 | 1.13 | 1.12 | 0.03 |
| 9 | Other agriculture and forestry | 0.285 | 0.83 | 1.07 | 0.02 |
| 10 | Animal husbandry | 0.245 | 1.13 | 1.13 | 0.03 |
| 11 | Dairy products | 0.018 | 16.93 | 15.72 | 0.10 |
| 12 | Grain mill products | 0.015 | 12.10 | 12.02 | 0.15 |
| 13 | Sugar and confectionery | 0.068 | 2.02 | 4.75 | 0.16 |
| 14 | Edible oils and other food-processing industries | 0.036 | 3.03 | 3.23 | 0.09 |
| 15 | Breweries and beverages | 0.063 | 0.28 | 1.51 | 0.04 |
| 16 | Textiles | 0.111 | 1.57 | 1.13 | 0.01 |
| 17 | Cotton ginning, pressing, and other textiles | 0.020 | 6.43 | 6.60 | 0.11 |
| 18 | Sawmills and wooden containers | 0.107 | 2.94 | 2.88 | 0.14 |
| 19 | Furniture and fixtures | 0.135 | 1.78 | 1.77 | 0.09 |
| 20 | Printing and publishing | 0.238 | 0.60 | 1.03 | 0.01 |
| 21 | Rubber and leather products | 0.104 | 1.07 | 1.09 | 0.01 |
| 22 | Basic chemicals, including fertilizers | 0.046 | 1.35 | 2.06 | 0.01 |
| 23 | Other chemicals | 0.035 | 0.44 | 1.37 | 0.01 |
| 24 | Glass and mineral products | 0.126 | 1.09 | 1.01 | 0.00 |
| 25 | Basic metal industries | 0.063 | 0.74 | 1.04 | 0.00 |
| 26 | Metal products | 0.118 | 1.10 | 1.09 | 0.01 |
| 27 | Machinery, except electrical | 0.113 | 0.88 | 1.15 | 0.01 |
| 28 | Electrical machinery | 0.061 | 1.29 | 1.42 | 0.02 |
| 29 | Railroad equipment | 0.326 | 1.03 | 1.03 | 0.00 |
| 30 | Transport equipment | 0.085 | 1.32 | 1.30 | 0.02 |
| 31 | Repair of transport equipment | 0.296 | 1.06 | 1.06 | 0.01 |
| 32 | Motorcycles and bicycles | 0.057 | 1.52 | 1.28 | 0.01 |
| 33 | Scientific and surgical instruments | 0.169 | 1.06 | 1.05 | 0.01 |
| 34 | Miscellaneous industries | 0.128 | 1.50 | 1.50 | 0.05 |
| 35 | Construction | 0.350 | 1.44 | 1.44 | 0.05 |
| 36 | Electricity | 0.137 | 1.05 | 1.00 | 0.00 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

mill products followed by dairy products, cotton ginning, edible oils, sugar, basic chemicals, sawmills, other chemicals, furniture and fixtures, and breweries (Table 42). In 1979/80 the highest value of direct, indirect and induced wage income multipliers was in the agroprocessing industries such as breweries, dairy products, grain mill products, edible oils, and sugar. Among the other manufacturing sectors, basic metals, electrical machinery, and basic chemicals also had high values (Table 43).

## Table 41—Direct and indirect sectoral wage incomes and multipliers in Punjab, with import leakages, 1979/80

| Sector Number | Sector | Wages per Unit of Output | Wage Multipliers per Unit of Final Demand | Wage Multipliers per Unit of Output | Indirect Wages per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.139 | 1.28 | 1.24 | 0.03 |
| 2 | Rice | 0.218 | 1.01 | 1.11 | 0.02 |
| 3 | Cotton | 0.210 | 1.02 | 1.12 | 0.03 |
| 4 | Sugarcane | 0.182 | 1.09 | 1.10 | 0.02 |
| 5 | Gram and pulses | 0.206 | 0.59 | 1.09 | 0.02 |
| 6 | Oilseeds | 0.129 | 0.71 | 1.17 | 0.02 |
| 7 | Other agriculture and forestry | 0.213 | 0.73 | 1.03 | 0.01 |
| 8 | Animal husbandry | 0.213 | 1.25 | 1.28 | 0.06 |
| 9 | Dairy products and confectionery | 0.038 | 2.24 | 5.16 | 0.16 |
| 10 | Grain mill products | 0.045 | 3.98 | 5.02 | 0.18 |
| 11 | Bakery products | 0.233 | 0.76 | 1.50 | 0.12 |
| 12 | Sugar | 0.079 | 0.76 | 2.99 | 0.16 |
| 13 | Other food industries | 0.122 | 1.42 | 2.17 | 0.14 |
| 14 | Edible oils | 0.030 | 3.56 | 3.80 | 0.08 |
| 15 | Breweries and beverages | 0.031 | 3.38 | 5.48 | 0.14 |
| 16 | Ginning and textiles | 0.101 | 2.34 | 1.57 | 0.06 |
| 17 | Sawmills and wooden goods | 0.267 | 1.06 | 1.21 | 0.06 |
| 18 | Paper, printing, and publishing | 0.281 | 0.25 | 1.26 | 0.07 |
| 19 | Rubber and leather products | 0.155 | 1.01 | 1.47 | 0.07 |
| 20 | Basic chemicals, including fertilizers | 0.051 | 0.75 | 2.07 | 0.06 |
| 21 | Drugs and pharmaceuticals | 0.090 | 0.05 | 2.12 | 0.10 |
| 22 | Other chemicals | 0.073 | 0.12 | 2.45 | 0.11 |
| 23 | Glass and mineral products | 0.108 | 1.45 | 1.51 | 0.06 |
| 24 | Basic metal industries | 0.039 | 2.42 | 3.13 | 0.08 |
| 25 | Metal products | 0.131 | 1.78 | 1.71 | 0.09 |
| 26 | Machinery, except electrical | 0.106 | 0.95 | 1.96 | 0.10 |
| 27 | Electrical machinery | 0.060 | 1.33 | 2.70 | 0.10 |
| 28 | Railroad equipment | 0.249 | 1.41 | 1.32 | 0.08 |
| 29 | Motor vehicles, manufacture and repair | 0.242 | 1.23 | 1.33 | 0.08 |
| 30 | Bicycles and parts | 0.099 | 2.19 | 2.16 | 0.12 |
| 31 | Scientific and surgical instruments | 0.156 | 0.38 | 1.61 | 0.10 |
| 32 | Sports and athletic goods | 0.150 | 1.89 | 1.90 | 0.13 |
| 33 | Miscellaneous industries | 0.296 | 0.78 | 1.12 | 0.04 |
| 34 | Electricity, gas, and water supply | 0.175 | 0.95 | 1.05 | 0.01 |
| 35 | Construction | 0.248 | 1.85 | 1.85 | 0.21 |
| 36 | Trade, transport, and storage | 0.405 | 1.29 | 1.14 | 0.06 |
| 37 | Other services | 0.457 | 1.26 | 1.18 | 0.08 |
| 38 | Banking and insurance | 0.439 | 1.16 | 1.06 | 0.03 |
| 39 | Real estate and ownership of dwellings | 0.131 | 1.02 | 1.02 | 0.00 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

## Conclusions on Income and Employment Multipliers

The main results of the multiplier analysis are summed up as follows. In 1969/70 the predominance of the primary sector, with traditional agriculture and rather limited interindustry linkages, indicated the relative backwardness of the Punjab economy. But with the rapid growth of agriculture and other sectors of the economy, the interindustry linkages strengthened, leading to higher generation of indirect income and employment.

## Table 42—Direct, indirect, and induced sectoral wage incomes and multipliers in Punjab, with import leakages, 1969/70

| Sector Number | Sector | Wages per Unit of Output | Wage Multipliers per Unit of Final Demand | Wage Multipliers per Unit of Output | Indirect and Induced Wages per Unit of a Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.217 | 2.24 | 1.71 | 0.15 |
| 2 | Rice | 0.265 | 1.97 | 1.88 | 0.23 |
| 3 | Maize | 0.299 | 1.88 | 1.80 | 0.24 |
| 4 | Cotton | 0.266 | 1.80 | 1.83 | 0.22 |
| 5 | Sugarcane | 0.289 | 2.06 | 1.81 | 0.23 |
| 6 | Gram and pulses | 0.213 | 2.22 | 2.17 | 0.25 |
| 7 | Oilseeds | 0.213 | 1.01 | 2.19 | 0.25 |
| 8 | Bajra | 0.208 | 2.35 | 2.32 | 0.28 |
| 9 | Other agriculture and forestry | 0.285 | 1.50 | 1.76 | 0.22 |
| 10 | Animal husbandry | 0.245 | 2.07 | 1.49 | 0.12 |
| 11 | Dairy products | 0.018 | 14.61 | 13.56 | 0.22 |
| 12 | Grain mill products | 0.015 | 29.75 | 27.71 | 0.40 |
| 13 | Sugar and confectionery | 0.068 | 2.20 | 5.14 | 0.28 |
| 14 | Edible oils and other food-processing industries | 0.036 | 5.77 | 6.07 | 0.18 |
| 15 | Breweries and beverages | 0.063 | 0.50 | 2.72 | 0.11 |
| 16 | Textiles | 0.111 | 2.45 | 1.71 | 0.08 |
| 17 | Cotton ginning, pressing, and other textiles | 0.020 | 9.55 | 9.71 | 0.17 |
| 18 | Sawmills and wooden containers | 0.107 | 4.07 | 4.00 | 0.32 |
| 19 | Furniture and fixtures | 0.135 | 2.90 | 2.90 | 0.26 |
| 20 | Printing and publishing | 0.238 | 0.89 | 1.53 | 0.13 |
| 21 | Rubber and leather products | 0.104 | 2.03 | 2.06 | 0.11 |
| 22 | Basic chemicals, including fertilizers | 0.046 | 3.29 | 4.97 | 0.18 |
| 23 | Other chemicals | 0.035 | 1.17 | 3.58 | 0.09 |
| 24 | Glass and mineral products | 0.126 | 1.74 | 1.60 | 0.08 |
| 25 | Basic metal industries | 0.063 | 1.18 | 1.66 | 0.04 |
| 26 | Metal products | 0.118 | 1.89 | 1.87 | 0.10 |
| 27 | Machinery, except electrical | 0.113 | 1.50 | 1.97 | 0.11 |
| 28 | Electrical machinery | 0.061 | 2.35 | 2.60 | 0.10 |
| 29 | Railroad equipment | 0.326 | 1.63 | 1.63 | 0.21 |
| 30 | Transport equipment | 0.085 | 2.42 | 2.38 | 0.12 |
| 31 | Repair of transport equipment | 0.296 | 1.45 | 1.45 | 0.13 |
| 32 | Motorcycles and bicycles | 0.057 | 3.22 | 2.71 | 0.10 |
| 33 | Scientific and surgical instruments | 0.169 | 2.07 | 2.06 | 0.18 |
| 34 | Miscellaneous industries | 0.128 | 2.31 | 2.30 | 0.17 |
| 35 | Construction | 0.350 | 1.56 | 1.56 | 0.20 |
| 36 | Electricity | 0.137 | 2.83 | 2.67 | 0.23 |

Source: Based on authors' calculations from Punjab input-output table for 1969/70 in Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980).

Compared with 1969/70, the indirect gains in value added, wage income, and employment are more evenly spread out among many more industries in 1979/80.

Whereas relatively high direct income and employment were generated in the agricultural sectors in 1979/80, the indirect income and employment generated by them were the lowest. On the other hand, the industrial sector in general and agroprocessing industries in particular, with low direct income and employment, showed much greater indirect income and employment gains than the agricultural sectors.

Between 1969/70 and 1979/80, a significant change seems to have taken place within the industrial sectors of Punjab. In 1969/70, it was the agriculture-based and

## Table 43—Direct, indirect, and induced sectoral wage incomes and multipliers in Punjab, with import leakages, 1979/80

| Sector Number | Sector | Wages per Unit of Output | Wage Multipliers per Unit of Final Demand | Wage Multipliers per Unit of Output | Indirect and Induced Wages per Unit of Output |
|---|---|---|---|---|---|
| | | (Rs) | | | (Rs) |
| 1 | Wheat | 0.139 | 2.48 | 2.23 | 0.17 |
| 2 | Rice | 0.218 | 1.96 | 1.95 | 0.21 |
| 3 | Cotton | 0.210 | 1.88 | 2.04 | 0.22 |
| 4 | Sugarcane | 0.182 | 2.27 | 2.25 | 0.23 |
| 5 | Gram and pulses | 0.206 | 1.13 | 2.07 | 0.22 |
| 6 | Oilseeds | 0.129 | 1.75 | 2.87 | 0.24 |
| 7 | Other agriculture and forestry | 0.213 | 1.46 | 1.90 | 0.19 |
| 8 | Animal husbandry | 0.213 | 2.26 | 1.99 | 0.21 |
| 9 | Dairy products and confectionery | 0.038 | 4.05 | 9.23 | 0.32 |
| 10 | Grain mill products | 0.045 | 6.90 | 8.36 | 0.34 |
| 11 | Bakery products | 0.233 | 1.12 | 2.21 | 0.28 |
| 12 | Sugar | 0.079 | 1.38 | 5.42 | 0.35 |
| 13 | Other food industries | 0.122 | 2.34 | 3.56 | 0.31 |
| 14 | Edible oils | 0.030 | 6.25 | 6.58 | 0.17 |
| 15 | Breweries and beverages | 0.031 | 5.74 | 9.28 | 0.25 |
| 16 | Ginning and textiles | 0.101 | 3.57 | 2.30 | 0.13 |
| 17 | Sawmills and wooden goods | 0.267 | 1.47 | 1.67 | 0.18 |
| 18 | Paper, printing, and publishing | 0.281 | 0.34 | 1.70 | 0.20 |
| 19 | Rubber and leather products | 0.155 | 1.49 | 2.14 | 0.18 |
| 20 | Basic chemicals, including fertilizers | 0.051 | 1.41 | 3.86 | 0.15 |
| 21 | Drugs and pharmaceuticals | 0.090 | 0.07 | 3.24 | 0.20 |
| 22 | Other chemicals | 0.073 | 0.19 | 3.95 | 0.22 |
| 23 | Glass and mineral products | 0.108 | 2.50 | 2.59 | 0.17 |
| 24 | Basic metal industries | 0.039 | 3.60 | 4.65 | 0.14 |
| 25 | Metal products | 0.131 | 2.52 | 2.42 | 0.19 |
| 26 | Machinery, except electrical | 0.106 | 1.40 | 2.90 | 0.20 |
| 27 | Electrical machinery | 0.060 | 2.16 | 4.36 | 0.20 |
| 28 | Railroad equipment | 0.249 | 2.03 | 1.90 | 0.22 |
| 29 | Motor vehicles, manufacture and repair | 0.242 | 1.73 | 1.88 | 0.21 |
| 30 | Bicycles and parts | 0.099 | 3.53 | 3.48 | 0.24 |
| 31 | Scientific and surgical instruments | 0.156 | 0.56 | 2.35 | 0.21 |
| 32 | Sports and athletic goods | 0.150 | 2.72 | 2.73 | 0.26 |
| 33 | Miscellaneous industries | 0.296 | 1.25 | 1.79 | 0.23 |
| 34 | Electricity, gas, and water supply | 0.175 | 1.72 | 1.88 | 0.15 |
| 35 | Construction | 0.248 | 2.59 | 2.58 | 0.39 |
| 36 | Trade, transport, and storage | 0.405 | 1.80 | 1.37 | 0.15 |
| 37 | Other services | 0.457 | 1.67 | 1.51 | 0.23 |
| 38 | Banking and insurance | 0.431 | 1.71 | 1.55 | 0.24 |
| 39 | Real estate and ownership of dwellings | 0.131 | 2.31 | 2.26 | 0.17 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).

food processing industries such as grain mill products, sawmills, sugar and confectionery, dairy products, cotton ginning, furniture, and edible oils that had the highest indirect income and employment gains. A distinguishing feature of all these sectors was that they obtained almost all of their raw materials from local sources. In 1979/80, in addition to the agroprocessing industries, some other basic and machine good industries, such as basic metals, metal products, other chemicals, electrical and nonelectrical machine goods, and drugs and pharmaceuticals, also recorded relatively higher indirect income and employment gains. It is significant that trade and transport, other services, banking, and real estate in the tertiary sector also generated fairly high levels of indirect incomes. This suggests a gradual expansion and deepening of the industrial structure in the state.

The value of consumption multipliers in 1969/70 was 1.86, suggesting that consumption-oriented activity in the state had a substantial impact despite large imports of industrial and consumer goods. In 1979/80, the consumption multipliers had a value of 1.62, indicating that consumption-based activity continued to be highly important for the economy. The highest induced-income and employment gains were recorded by the sectors that occupy an important place in the consumption basket—primarily agriculture-based industries. However, because of direct and indirect effects, some other industries in heavy and basic areas also became important. In addition to the manufacturing sectors, construction emerged as significant in the generation of indirect as well as induced income and employment.

## 7

# CONCLUSIONS AND POLICY IMPLICATIONS

The main conclusion of this study is that rapid agricultural transformation is a potent instrument for bringing about significant acceleration in the overall growth and transformation of a labor-surplus economy dominated by the agricultural sector. In the case of Punjab, after adoption of the new seed-fertilizer technology there was a marked increase in the growth rate of agriculture, which in turn accelerated growth in other sectors of the state economy through input, output, and consumption linkages.

The technology improvement and upgrading in agriculture and other sectors of the economy resulted in more roundabout methods of production and a higher use of intermediate inputs, thereby strengthening interindustry linkages. Further, significant increases in per capita income led to much higher demand for consumption goods, and since meeting the consumption needs of the people constitutes a major economic activity in the state, the inducement effects of consumption were also quite substantial.

In short, rapid agricultural growth, by raising the incomes of an overwhelmingly large proportion of the labor force, not only made a deep dent in rural poverty but also led to development of other sectors through forward and backward linkage effects. It should, however, be noted that the direct and indirect effects of increased economic activity in both agriculture and manufacturing in Punjab have been considerably reduced, since the state is a large importer of modern agricultural inputs such as fertilizers, insecticides, and diesel fuel; raw materials for manufacturing such as coal, pig iron, and metals; and numerous finished goods for consumption. On the other hand, Punjab has benefited immensely from the existence of an assured market for exports of agricultural surpluses and industrial products and from the easy availability of inputs such as fertilizers and diesel fuel at nationally subsidized rates.

With the rapid development of the economy, the nature and quantum of forward and backward linkages being generated in the economy has grown significantly, indicating a deepening of intersectoral relationships. A comparative analysis of the 1969/70 and 1979/80 input-output tables for Punjab shows that by 1979/80, besides the agriculture and agroprocessing sectors, many machine-based and metal-based industries as well as trade, transport, banking, real estate, and other services were generating high forward and backward linkages despite large import leakages. The multiplier analysis confirms that between 1969/70 and 1979/80, not only the farm sectors and agroprocessing industries, but sectors such as basic metals, metal products, machine goods, electrical and nonelectrical machinery, and construction as well as most tertiary services began to record high indirect and induced income and employment.

Some useful lessons in development strategy can be learned from the Punjab model of growth. The Punjab experience demonstrates that it is possible for a region within a large country to enjoy the fruits of specialization and comparative advantage through trade and integration with the rest of the country. The state was able to export large agricultural surpluses and some industrial products to the rest of India at favorable prices and also obtained various inputs for modernized agriculture and industry from the rest of the country. This enabled Punjab to exploit fully its comparative advantage in rice, wheat, and cotton production and in agroprocessing and other industries.

Although substantial resources were transferred to Punjab for both rehabilitation and infrastructural investment for many years after independence, there is evidence to suggest that a large outflow of funds from the state has been invested in the rest of India since Punjab became highly surplus in agricultural production. Simultaneously, a large number of agricultural laborers migrated to Punjab from Bihar and other relatively less-developed states of India. Thus, in the context of an "open" regional economy, the gains of development are being shared with the rest of the economy.

Finally, Punjab was able to pioneer the green revolution and thereby transform its agriculture. Its rapid overall growth was due primarily to the state's large investments in irrigation, power, roads, communications, and other rural and urban infrastructure. These investments were financed both through large central plan transfers and through resources internally mobilized by the state. The availability of this infrastructure was mainly responsible for the adaptation of the Mexican seed-fertilizer technology to local conditions and for its rapid spread and successful exploitation by Punjab farmers. The policymakers were also able to create an appropriate institutional framework that assured the farmers of remunerative prices for all produce brought by them to the market. The ensured profitability of the new technology gave surplus farmers the enthusiasm and confidence needed to undertake fairly large private investments in irrigation, land improvements, and other farm assets, thereby further supplementing public investment in rural infrastructure. The policy lesson to be learned from the Punjab experience is that large investment in rural and urban infrastructure is a precondition for agricultural development and for rapid growth of both agriculture and other sectors of the economy.

# APPENDIX 1: SUPPLEMENTARY TABLES

## Table 44—Interindustry flows and patterns of final demand in Punjab, 1979/80

| Sector Number | Sector | Wheat (1) | Rice (2) | Cotton (3) | Sugarcane (4) | Gram and Pulses (5) |
|---|---|---|---|---|---|---|
| | | | | (Rs 1,000) | | |
| 1 | Wheat | 273,595 | 0 | 0 | 0 | 0 |
| 2 | Rice | 0 | 85,781 | 0 | 0 | 0 |
| 3 | Cotton | 0 | 0 | 17,938 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 0 | 29,660 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 0 | 19,448 |
| 6 | Oilseeds | 0 | 0 | 0 | 0 | 0 |
| 7 | Other agriculture and forestry | 0 | 0 | 0 | 0 | 0 |
| 8 | Animal husbandry | 269,649 | 75,116 | 79,401 | 30,925 | 24,329 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 0 | 0 |
| 10 | Grain mill products | 0 | 0 | 0 | 0 | 0 |
| 11 | Bakery products | 0 | 0 | 0 | 0 | 0 |
| 12 | Sugar | 0 | 0 | 0 | 0 | 0 |
| 13 | Other food industries | 0 | 0 | 0 | 0 | 0 |
| 14 | Edible oils | 0 | 0 | 0 | 0 | 0 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 0 | 0 | 0 | 0 |
| 17 | Sawmills and wooden goods | 0 | 0 | 0 | 0 | 0 |
| 18 | Paper, printing, and publishing | 0 | 0 | 0 | 0 | 0 |
| 19 | Rubber and leather products | 0 | 0 | 0 | 0 | 0 |
| 20 | Basic chemicals, including fertilizers | 1,406,021 | 650,145 | 214,913 | 35,677 | 1,249 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 0 | 0 | 0 |
| 22 | Other chemicals | 0 | 0 | 0 | 0 | 0 |
| 23 | Glass and mineral products | 0 | 0 | 0 | 0 | 0 |
| 24 | Basic metal industries | 0 | 0 | 0 | 0 | 0 |
| 25 | Metal products | 0 | 0 | 0 | 0 | 0 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 0 | 0 | 0 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 0 | 0 | 0 | 0 | 0 |
| 34 | Electricity, gas, and water supply | 175,302 | 51,757 | 10,200 | 9,678 | 0 |
| 35 | Construction | 0 | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 291,269 | 117,747 | 39,609 | 6,688 | 4,298 |
| 37 | Other services | 0 | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 33,335 | 16,790 | 5,101 | 1,266 | 886 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 2,449,171 | 997,336 | 367,162 | 113,894 | 50,210 |
| 41 | Noncompetitive imports | 1,334,025 | 452,875 | 156,385 | 27,041 | 40,316 |
| 42 | Repair and maintenance | 80,807 | 41,782 | 18,230 | 6,753 | 3,973 |
| 43 | Work done by others | 0 | 0 | 0 | 0 | 0 |
| 44 | Taxes, duties, subsidy | 85,968 | 70,420 | 19,610 | 5,217 | 3,264 |
| 45 | Consumable stores | 0 | 0 | 0 | 0 | 0 |
| 46 | Depreciation | 363,589 | 52,366 | 61,586 | 10,654 | 15,939 |
| 47 | Net value added | 5,420,991 | 3,573,970 | 1,573,118 | 649,892 | 364,902 |
| 48 | Gross output | 9,734,551 | 5,188,749 | 2,196,091 | 813,451 | 478,604 |
| 49 | Workers (in number of persons) | 546,440 | 560,383 | 224,272 | 70,039 | 49,703 |
| 50 | Person-days (in thousands of days) | 142,621 | 146,260 | 58,535 | 18,280 | 12,972 |
| 51 | Wages | 1,349,296 | 1,131.974 | 460,498 | 148,412 | 98,511 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Oilseeds (6) | Other Agriculture and Forestry (7) | Animal Husbandry (8) | Dairy Products and Confectionery (9) |
|---|---|---|---|---|---|
| | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 356,830 | 0 |
| 2 | Rice | 0 | 0 | 194,374 | 0 |
| 3 | Cotton | 0 | 0 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 20,085 | 0 |
| 5 | Gram and pulses | 0 | 0 | 129,939 | 412 |
| 6 | Oilseeds | 1,558 | 0 | 0 | 0 |
| 7 | Other agriculture and forestry | 0 | 82,720 | 490,072 | 1,209 |
| 8 | Animal husbandry | 23,225 | 34,255 | 0 | 210,016 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 46,482 |
| 10 | Grain mill products | 0 | 0 | 0 | 1,201 |
| 11 | Bakery products | 0 | 0 | 0 | 110 |
| 12 | Sugar | 0 | 0 | 0 | 28,882 |
| 13 | Other food industries | 0 | 0 | 0 | 645 |
| 14 | Edible oils | 0 | 0 | 258,320 | 2,707 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 0 | 751,694 | 0 |
| 17 | Sawmills and wooden goods | 0 | 0 | 0 | 105 |
| 18 | Paper, printing, and publishing | 0 | 0 | 0 | 994 |
| 19 | Rubber and leather products | 0 | 0 | 0 | 0 |
| 20 | Basic chemicals, including fertilizers | 18,960 | 3,489 | 0 | 3,599 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 14,769 | 0 |
| 22 | Other chemicals | 0 | 0 | 0 | 111 |
| 23 | Glass and mineral products | 0 | 0 | 0 | 3 |
| 24 | Basic metal industries | 0 | 0 | 0 | 0 |
| 25 | Metal products | 0 | 0 | 0 | 99,102 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 0 | 0 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 0 | 0 | 0 | 2 |
| 34 | Electricity, gas, and water supply | 2,021 | 5,186 | 0 | 2,066 |
| 35 | Construction | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 3,659 | 7,180 | 103,017 | 38,348 |
| 37 | Other services | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 1,057 | 4,286 | 35,100 | 10,163 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 50,480 | 167,116 | 2,354,200 | 446,157 |
| 41 | Noncompetitive imports | 15,380 | 34,130 | 0 | 29,302 |
| 42 | Repair and maintenance | 3,770 | 33,885 | 0 | 4,451 |
| 43 | Work done by others | 0 | 0 | 0 | 1,689 |
| 44 | Taxes, duties, subsidy | 6,106 | 18,022 | 23,400 | 20,397 |
| 45 | Consumable stores | 0 | 0 | 0 | 4,513 |
| 46 | Depreciation | 1,138 | 243,380 | 100 | 7,693 |
| 47 | Net value added | 366,971 | 2,447,710 | 5,598,200 | 154,820 |
| 48 | Gross output | 454,093 | 2,944,243 | 7,975,900 | 669,022 |
| 49 | Workers (in number of persons) | 24,935 | 305,759 | 828,295 | 5,204 |
| 50 | Person-days (in thousands of days) | 6,508 | 79,803 | 216,185 | 1,325 |
| 51 | Wages | 58,434 | 626,806 | 1,698,005 | 25,695 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Grain Mill Products (10) | Bakery Products (11) | Sugar (12) | Other Food Industries (13) | Edible Oils (14) |
|---|---|---|---|---|---|---|
| | | | | (Rs 1,000) | | |
| 1 | Wheat | 1,249,251 | 0 | 0 | 382 | 0 |
| 2 | Rice | 58,457 | 0 | 0 | 0 | 3,482 |
| 3 | Cotton | 0 | 0 | 0 | 0 | 32,506 |
| 4 | Sugarcane | 0 | 0 | 122,405 | 0 | 0 |
| 5 | Gram and pulses | 67,143 | 0 | 0 | 0 | 0 |
| 6 | Oilseeds | 501 | 0 | 0 | 0 | 582,654 |
| 7 | Other agriculture and forestry | 22,069 | 6,553 | 0 | 128,193 | 2,921 |
| 8 | Animal husbandry | 0 | 5,892 | 1,188 | 74,773 | 0 |
| 9 | Dairy products and confectionery | 0 | 370 | 1,076 | 473 | 0 |
| 10 | Grain mill products | 0 | 44,802 | 0 | 10,710 | 2,020 |
| 11 | Bakery products | 0 | 0 | 0 | 0 | 0 |
| 12 | Sugar | 0 | 11,765 | 0 | 13,048 | 0 |
| 13 | Other food industries | 0 | 1,074 | 0 | 7,715 | 98 |
| 14 | Edible oils | 0 | 13,783 | 0 | 15,979 | 708,954 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 0 | 0 | 0 | 39,581 |
| 17 | Sawmills and wooden goods | 0 | 0 | 0 | 1,584 | 0 |
| 18 | Paper, printing, and publishing | 2,799 | 1,441 | 405 | 855 | 1,526 |
| 19 | Rubber and leather products | 0 | 1,585 | 0 | 618 | 0 |
| 20 | Basic chemicals, including fertilizers | 49 | 2,975 | 889 | 2,817 | 7,442 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 0 | 1,696 | 1,020 |
| 22 | Other chemicals | 0 | 12 | 0 | 3,384 | 0 |
| 23 | Glass and mineral products | 0 | 0 | 276 | 8,221 | 0 |
| 24 | Basic metal industries | 0 | 0 | 0 | 1,439 | 0 |
| 25 | Metal products | 0 | 0 | 0 | 7,675 | 47,121 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 0 | 0 | 0 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 0 | 0 | 0 | 0 | 171 |
| 34 | Electricity, gas, and water supply | 10,967 | 941 | 1,234 | 12,184 | 13,988 |
| 35 | Construction | 0 | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 110,570 | 8,212 | 10,501 | 24,303 | 141,194 |
| 37 | Other services | 0 | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 62,411 | 755 | 0 | 20,504 | 0 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 1,584,217 | 100,160 | 137,974 | 336,553 | 1,584,678 |
| 41 | Noncompetitive imports | 20,474 | 304 | 7,132 | 18,081 | 27,062 |
| 42 | Repair and maintenance | 36,244 | 1,228 | 6,036 | 7,102 | 34,232 |
| 43 | Work done by others | 12,027 | 0 | 581 | 700 | 10,719 |
| 44 | Taxes, duties, subsidy | 19,028 | 74 | 2,422 | 1,368 | 38,708 |
| 45 | Consumable stores | 31,121 | 352 | 2,662 | 3,253 | 21,127 |
| 46 | Depreciation | 14,029 | 651 | 4,217 | 4,346 | 19,042 |
| 47 | Net value added | 156,845 | 52,913 | 34,109 | 140,429 | 140,382 |
| 48 | Gross output | 1,873,985 | 155,682 | 195,133 | 511,832 | 1,875,950 |
| 49 | Workers (in number of persons) | 23,913 | 11,337 | 4,559 | 16,979 | 13,939 |
| 50 | Person-days (in thousands of days) | 5,724 | 2,966 | 992 | 4,633 | 3,036 |
| 51 | Wages | 83,999 | 36,324 | 15,335 | 62,580 | 56,448 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Breweries and Beverages (15) | Ginning and Textiles (16) | Sawmills and Wooden Goods (17) | Paper, Printing, and Publishing (18) |
|---|---|---|---|---|---|
| | | (Rs 1,000) | | | |
| 1 | Wheat | 0 | 0 | 0 | 0 |
| 2 | Rice | 0 | 0 | 0 | 0 |
| 3 | Cotton | 0 | 732,467 | 0 | 0 |
| 4 | Sugarcane | 1,725 | 0 | 0 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 0 |
| 6 | Oilseeds | 0 | 16,330 | 0 | 0 |
| 7 | Other agriculture and forestry | 8,843 | 5,274 | 19,026 | 0 |
| 8 | Animal husbandry | 0 | 179,918 | 0 | 0 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 0 |
| 10 | Grain mill products | 0 | 273 | 0 | 174 |
| 11 | Bakery products | 0 | 0 | 0 | 0 |
| 12 | Sugar | 35,005 | 0 | 0 | 0 |
| 13 | Other food industries | 14,390 | 10,423 | 0 | 0 |
| 14 | Edible oils | 0 | 0 | 0 | 0 |
| 15 | Breweries and beverages | 26,545 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 3,346,826 | 3,111 | 815 |
| 17 | Sawmills and wooden goods | 218 | 12,920 | 207,786 | 9,846 |
| 18 | Paper, printing, and publishing | 7,520 | 17,412 | 2,012 | 42,832 |
| 19 | Rubber and leather products | 10,919 | 22,939 | 15,910 | 65 |
| 20 | Basic chemicals, including fertilizers | 2,695 | 14,015 | 3,601 | 20 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 0 | 0 |
| 22 | Other chemicals | 2,741 | 38,495 | 4,700 | 2,108 |
| 23 | Glass and mineral products | 31,426 | 0 | 3,076 | 947 |
| 24 | Basic metal industries | 1,346 | 0 | 27,935 | 11,559 |
| 25 | Metal products | 3,590 | 12,386 | 7,482 | 163 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 0 | 0 | 257 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 173 | 7,527 | 63 | 1,377 |
| 34 | Electricity, gas, and water supply | 6,206 | 55,777 | 4,104 | 1,388 |
| 35 | Construction | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 18,632 | 329,445 | 37,173 | 9,975 |
| 37 | Other services | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 27,420 | 7 | 2,848 | 968 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 199,394 | 4,802,434 | 339,084 | 82,448 |
| 41 | Noncompetitive imports | 12,331 | 78,118 | 1,204 | 892 |
| 42 | Repair and maintenance | 7,074 | 117,580 | 2,026 | 1,106 |
| 43 | Work done by others | 5,955 | 369,463 | 1,870 | 5,068 |
| 44 | Taxes, duties, subsidy | 4,115 | 147,430 | 12,037 | 1,481 |
| 45 | Consumable stores | 2,682 | 110,729 | 10,671 | 1,247 |
| 46 | Depreciation | 5,802 | 55,006 | 146 | 627 |
| 47 | Net value added | 47,383 | 1,251,349 | 234,077 | 50,768 |
| 48 | Gross output | 284,736 | 6,932,109 | 601,115 | 143,637 |
| 49 | Workers (in number of persons) | 2,493 | 169,678 | 45,710 | 10,954 |
| 50 | Person-days (in thousands of days) | 827 | 52,015 | 13,275 | 3,481 |
| 51 | Wages | 8,724 | 697,546 | 160,533 | 40,299 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Rubber and Leather Products (19) | Basic Chemicals, Including Fertilizers (20) | Drugs and Pharmaceuticals (21) | Other Chemicals (22) | Glass and Mineral Products (23) |
|---|---|---|---|---|---|---|
| | | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 0 | 0 | 0 |
| 2 | Rice | 0 | 0 | 0 | 0 | 0 |
| 3 | Cotton | 0 | 0 | 91 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 0 | 0 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 0 | 0 |
| 6 | Oilseeds | 1,468 | 0 | 0 | 12,054 | 0 |
| 7 | Other agriculture and forestry | 970 | 188 | 3,307 | 35,272 | 452 |
| 8 | Animal husbandry | 62,680 | 1,052 | 27 | 4,118 | 0 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 9 | 0 |
| 10 | Grain mill products | 659 | 0 | 0 | 6,119 | 0 |
| 11 | Bakery products | 0 | 0 | 0 | 0 | 0 |
| 12 | Sugar | 0 | 0 | 2,151 | 0 | 0 |
| 13 | Other food industries | 2,318 | 0 | 0 | 0 | 0 |
| 14 | Edible oils | 221 | 1,999 | 0 | 7,340 | 0 |
| 15 | Breweries and beverages | 0 | 587 | 65 | 221 | 0 |
| 16 | Ginning and textiles | 29,954 | 0 | 81 | 407 | 0 |
| 17 | Sawmills and wooden goods | 2,159 | 4,948 | 549 | 516 | 0 |
| 18 | Paper, printing, and publishing | 15,915 | 5,086 | 1,749 | 4,470 | 3,321 |
| 19 | Rubber and leather products | 283,729 | 6,274 | 240 | 3,963 | 0 |
| 20 | Basic chemicals, including fertilizers | 45,202 | 62,514 | 6,499 | 27,040 | 293 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 4,503 | 0 | 0 |
| 22 | Other chemicals | 13,753 | 28,121 | 1,926 | 43,991 | 32,903 |
| 23 | Glass and mineral products | 0 | 728 | 2,300 | 9 | 635,756 |
| 24 | Basic metal industries | 14 | 0 | 364 | 0 | 84,573 |
| 25 | Metal products | 4,912 | 2,086 | 825 | 7,642 | 0 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 0 | 0 | 28 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 | 410 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 505 | 282 | 27 | 141 | 369 |
| 34 | Electricity, gas, and water supply | 7,387 | [illegible] | 535 | 2,416 | 3,237 |
| 35 | Construction | 0 | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 58,997 | 33,113 | 2,906 | 14,319 | 133,470 |
| 37 | Other services | 0 | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 6,752 | 51,747 | 770 | 6,504 | 4,521 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 537,595 | 275,342 | 28,943 | 176,551 | 899,305 |
| 41 | Noncompetitive imports | 84,739 | 205,143 | 1,064 | 7,179 | 12,143 |
| 42 | Repair and maintenance | 9,468 | 27,822 | 617 | 1,636 | 1,363 |
| 43 | Work done by others | 5,765 | 23,732 | 430 | 3,338 | 361 |
| 44 | Taxes, duties, subsidy | 6,935 | 20,613 | 282 | 2,064 | 9,338 |
| 45 | Consumable stores | 7,562 | 28,594 | 363 | 2,169 | 4,428 |
| 46 | Depreciation | 4,756 | 232,820 | 363 | 4,528 | 660 |
| 47 | Net value added | 233,414 | 270,537 | 6,595 | 36,014 | 560,756 |
| 48 | Gross output | 890,234 | 1,084,603 | 38,657 | 233,479 | 1,488,354 |
| 49 | Workers (in number of persons) | 38,397 | 4,974 | 1,020 | 4,874 | 42,954 |
| 50 | Person-days (in thousands of days) | 11,882 | 1,227 | 263 | 1,280 | 13,967 |
| 51 | Wages | 138,037 | 55,813 | 3,468 | 17,064 | 161,185 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Basic Metal Industries (24) | Metal Products (25) | Machinery, Except Electrical (26) | Electrical Machinery (27) | Railroad Equipment (28) |
|---|---|---|---|---|---|---|
| | | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 0 | 0 | 0 |
| 2 | Rice | 0 | 0 | 0 | 0 | 0 |
| 3 | Cotton | 0 | 0 | 0 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 0 | 0 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 0 | 0 |
| 6 | Oilseeds | 0 | 0 | 0 | 0 | 0 |
| 7 | Other agriculture and forestry | 1,030 | 105 | 790 | 66 | 16 |
| 8 | Animal husbandry | 0 | 0 | 0 | 0 | 0 |
| 9 | Dairy products and confectionery | 295,199 | 0 | 0 | 0 | 0 |
| 10 | Grain mill products | 0 | 0 | 0 | 5 | 0 |
| 11 | Bakery products | 0 | 0 | 0 | 0 | 0 |
| 12 | Sugar | 423 | 204 | 66 | 0 | 0 |
| 13 | Other food industries | 10 | 0 | 0 | 0 | 0 |
| 14 | Edible oils | 0 | 17 | 0 | 0 | 0 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 43 | 6 | 0 | 0 |
| 17 | Sawmills and wooden goods | 1,399 | 11,748 | 9,114 | 8,213 | 351 |
| 18 | Paper, printing and publishing | 6,197 | 4,435 | 5,198 | 10,221 | 311 |
| 19 | Rubber and leather products | 0 | 3,081 | 3,218 | 706 | 5,159 |
| 20 | Basic chemicals, including fertilizers | 16,630 | 9,373 | 8,786 | 30,789 | 54 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 0 | 0 | 0 |
| 22 | Other chemicals | 1,915 | 3,786 | 900 | 4,449 | 129 |
| 23 | Glass and mineral products | 2,372 | 0 | 92 | 7,166 | 0 |
| 24 | Basic metal industries | 926,256 | 652,933 | 389,041 | 187,900 | 11,776 |
| 25 | Metal products | 522,160 | 41,298 | 56,982 | 6,670 | 1,857 |
| 26 | Machinery, except electrical | 0 | 930 | 24,424 | 28,981 | 100 |
| 27 | Electrical machinery | 74,263 | 0 | 7,592 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 390 | 0 | 4,188 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 0 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 0 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 0 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 624 | 426 | 178 | 327 | 34 |
| 34 | Electricity, gas, and water supply | 53,509 | 13,834 | 6,779 | 2,936 | 940 |
| 35 | Construction | 0 | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 418,818 | 137,112 | 103,137 | 49,643 | 3,954 |
| 37 | Other services | 0 | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 6,544 | 4,366 | 69,021 | 0 | 854 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 2,327,349 | 883,691 | 625,714 | 344,072 | 29,723 |
| 41 | Noncompetitive imports | 1,244,672 | 80,236 | 166,587 | 29,475 | 2,525 |
| 42 | Repair and maintenance | 54,571 | 28,170 | 16,007 | 8,845 | 54 |
| 43 | Work done by others | 79,018 | 46,711 | 17,324 | 13,260 | 2,573 |
| 44 | Taxes, duties, subsidy | 21,330 | 3,930 | 2,065 | 1,870 | 91 |
| 45 | Consumable stores | 156,723 | 47,737 | 31,564 | 15,292 | 145 |
| 46 | Depreciation | 52,519 | 6,739 | 19,178 | 10,679 | 1,838 |
| 47 | Net value added | 392,054 | 280,160 | 240,583 | 112,296 | 28,265 |
| 48 | Gross output | 4,328,236 | 1,377,374 | 1,119,022 | 535,789 | 65,214 |
| 49 | Workers (in number of persons) | 37,271 | 52,504 | 26,795 | 8,060 | 2,379 |
| 50 | Person-days (in thousands of days) | 10,654 | 16,022 | 8,252 | 2,450 | 720 |
| 51 | Wages | 169,210 | 180,015 | 118,772 | 31,974 | 16,250 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Motor Vehicles, Manufacture and Repair (29) | Bicycles and Parts (30) | Scientific and Surgical Instruments (31) | Sports and Athletic Goods (32) | Miscellaneous Industries (33) |
|---|---|---|---|---|---|---|
| | | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 0 | 0 | 0 |
| 2 | Rice | 0 | 0 | 0 | 0 | 0 |
| 3 | Cotton | 0 | 0 | 0 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 0 | 0 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 0 | 0 |
| 6 | Oilseeds | 0 | 0 | 0 | 0 | 0 |
| 7 | Other agriculture and forestry | 364 | 1,328 | 36 | 426 | 215 |
| 8 | Animal husbandry | 0 | 0 | 0 | 1,398 | 12,698 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 0 | 0 |
| 10 | Grain mill products | 0 | 0 | 0 | 2 | 0 |
| 11 | Bakery products | 0 | 0 | 0 | 0 | 0 |
| 12 | Sugar | 0 | 0 | 0 | 0 | 0 |
| 13 | Other food industries | 0 | 0 | 0 | 351 | 0 |
| 14 | Edible oils | 0 | 0 | 0 | 0 | 0 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 0 | 0 |
| 16 | Ginning and textiles | 0 | 169 | 561 | 37,009 | 121 |
| 17 | Sawmills and wooden goods | 4,888 | 12,914 | 1,296 | 24,773 | 754 |
| 18 | Paper, printing, and publishing | 5,410 | 12,708 | 2,748 | 12,570 | 3,801 |
| 19 | Rubber and leather products | 5,856 | 42,696 | 414 | 115,894 | 550 |
| 20 | Basic chemicals, including fertilizers | 22,693 | 25,328 | 394 | 2,818 | 971 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 0 | 11,546 | 0 |
| 22 | Other chemicals | 4,846 | 18,148 | 41 | 0 | 79 |
| 23 | Glass and mineral products | 26 | 0 | 581 | 2,568 | 0 |
| 24 | Basic metal industries | 339,655 | 272,663 | 25,611 | 741 | 172 |
| 25 | Metal products | 9,325 | 202,731 | 105 | 0 | 64 |
| 26 | Machinery, except electrical | 0 | 0 | 0 | 0 | 0 |
| 27 | Electrical machinery | 1,020 | 0 | 0 | 0 | 0 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 20,924 | 0 | 267 | 0 | 0 |
| 30 | Bicycles and parts | 0 | 45,352 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 0 | 5,560 | 0 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 250 | 466 | 24 | 15,048 | 1,271 |
| 34 | Electricity, gas, and water supply | 16,852 | 7,863 | 803 | 1,885 | 3,694 |
| 35 | Construction | 0 | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 78,981 | 97,890 | 7,043 | 25,810 | 3,809 |
| 37 | Other services | 0 | 0 | 0 | 0 | 0 |
| 38 | Banking and insurance | 10,263 | 26,252 | 1,930 | 4,179 | 537 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 521,353 | 766,508 | 47,414 | 257,018 | 28,736 |
| 41 | Noncompetitive imports | 77,008 | 34,076 | 5,253 | 2,533 | 18,870 |
| 42 | Repair and maintenance | 18,529 | 19,097 | 716 | 10,472 | 1,787 |
| 43 | Work done by others | 13,450 | 29,358 | 2,991 | 16,787 | 703 |
| 44 | Taxes, duties, subsidy | 3,432 | 2,554 | 1,398 | 3,914 | 89 |
| 45 | Consumable stores | 27,358 | 37,412 | 2,091 | 18,693 | 9,128 |
| 46 | Depreciation | 12,688 | 12,004 | 1,235 | 897 | 514 |
| 47 | Net value added | 399,047 | 411,937 | 24,739 | 101,936 | 132,803 |
| 48 | Gross output | 1,072,865 | 1,312,946 | 85,837 | 412,250 | 192,630 |
| 49 | Workers (in number of persons) | 70,679 | 37,073 | 3,401 | 17,553 | 1,626 |
| 50 | Person-days (in thousands of days) | 21,950 | 11,844 | 1,043 | 5,395 | 500 |
| 51 | Wages | 259,321 | 129,755 | 13,420 | 61,732 | 57,104 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Electricity, Gas, and Water Supply (34) | Construction (35) | Trade, Transport, and Storage (36) | Other Services (37) |
|---|---|---|---|---|---|
| | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 0 | 46,410 |
| 2 | Rice | 0 | 0 | 0 | 75,769 |
| 3 | Cotton | 0 | 0 | 0 | 0 |
| 4 | Sugarcane | 0 | 0 | 0 | 0 |
| 5 | Gram and pulses | 0 | 0 | 0 | 5,697 |
| 6 | Oilseeds | 0 | 0 | 0 | 0 |
| 7 | Other agricultureand forestry | 0 | 116,258 | 13 | 26,614 |
| 8 | Animal husbandry | 0 | 0 | 60,185 | 47,281 |
| 9 | Dairy products and confectionery | 0 | 0 | 0 | 0 |
| 10 | Grain mill products | 0 | 0 | 0 | 0 |
| 11 | Bakery products | 0 | 0 | 0 | 8,811 |
| 12 | Sugar | 0 | 0 | 0 | 5,177 |
| 13 | Other food industries | 0 | 0 | 0 | 0 |
| 14 | Edible oils | 0 | 0 | 0 | 1,144 |
| 15 | Breweries and beverages | 0 | 0 | 0 | 280 |
| 16 | Ginning and textiles | 0 | 0 | 30,502 | 12,399 |
| 17 | Sawmills and wooden goods | 0 | 323,779 | 40,873 | 4,999 |
| 18 | Paper, printing, and publishing | 4,665 | 0 | 104,800 | 184,069 |
| 19 | Rubber and leather products | 0 | 0 | 177,676 | 14,983 |
| 20 | Basic chemicals, including fertilizers | 15 | 0 | 352 | 923 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 149 | 436,403 |
| 22 | Other chemicals | 0 | 51,857 | 643 | 503 |
| 23 | Glass and mineral products | 0 | 844,084 | 0 | 680 |
| 24 | Basic metal industries | 0 | 528,246 | 10,240 | 32,246 |
| 25 | Metal products | 0 | 14,149 | 12 | 85,968 |
| 26 | Machinery, except electrical | 0 | 0 | 25,269 | 11,954 |
| 27 | Electrical machinery | 0 | 454 | 23,322 | 7,659 |
| 28 | Railroad equipment | 0 | 0 | 56,126 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 0 | 101,252 | 14,175 |
| 30 | Bicycles and parts | 0 | 0 | 66,702 | 1,089 |
| 31 | Scientific and surgical instruments | 0 | 493 | 13,018 | 328,278 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 518 | 0 | 0 | 0 |
| 34 | Electricity, gas, and water supply | 62,076 | 44,257 | 186,068 | 174,685 |
| 35 | Construction | 0 | 0 | 0 | 0 |
| 36 | Trade, transport, and storage | 18,669 | 2,139,312 | 1,430,546 | 772,507 |
| 37 | Other services | 0 | 0 | 971,217 | 343,840 |
| 38 | Banking and insurance | 9,071 | 51,431 | 318,637 | 46,849 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 0 |
| 40 | Total inputs | 95,014 | 4,114,320 | 3,617,602 | 2,691,392 |
| 41 | Noncompetitive imports | 180,767 | 78,607 | 567,093 | 21,509 |
| 42 | Repair and maintenance | 141,503 | 0 | 0 | 0 |
| 43 | Work done by others | 116,909 | 0 | 0 | 0 |
| 44 | Taxes, duties, subsidy | 992 | 139,032 | 414,031 | 245,640 |
| 45 | Consumable stores | 1,314 | 0 | 0 | 0 |
| 46 | Depreciation | 174,782 | 127,600 | 593,300 | 58,600 |
| 47 | Net value added | 946,017 | 2,393,100 | 8,649,200 | 3,493,500 |
| 48 | Gross output | 1,657,298 | 6,852,659 | 13,841,230 | 6,510,641 |
| 49 | Workers (in number of persons) | 42,784 | 100,663 | 546,973 | 613,024 |
| 50 | Person-days (in thousands of days) | 11,980 | 24,360 | 171,203 | 178,906 |
| 51 | Wages | 289,600 | 1,699,101 | 5,602,138 | 2,973,820 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Banking and Insurance (38) | Real Estate and Ownership of Dwellings (39) | Intermediate Use (40) | Rural Consumption (41) |
|---|---|---|---|---|---|
| | | | (Rs 1,000) | | |
| 1 | Wheat | 0 | 0 | 1,926,468 | 1,387,629 |
| 2 | Rice | 0 | 0 | 417,874 | 225,304 |
| 3 | Cotton | 0 | 0 | 783,002 | 0 |
| 4 | Sugarcane | 0 | 0 | 173,875 | 517,155 |
| 5 | Gram and pulses | 0 | 0 | 222,639 | 508,144 |
| 6 | Oilseeds | 0 | 0 | 614,565 | 0 |
| 7 | Other agriculture and forestry | 0 | 0 | 954,330 | 1,899,159 |
| 8 | Animal husbandry | 0 | 0 | 1,198,126 | 3,225,604 |
| 9 | Dairy products and confectionery | 0 | 0 | 343,609 | 810,481 |
| 10 | Grain mill products | 0 | 0 | 66,165 | 1,500,654 |
| 11 | Bakery products | 0 | 0 | 8,921 | 77,963 |
| 12 | Sugar | 0 | 0 | 96,721 | 413,219 |
| 13 | Other food industries | 0 | 0 | 37,024 | 373,118 |
| 14 | Edible oils | 0 | 0 | 1,010,464 | 587,450 |
| 15 | Breweries and beverages | 0 | 0 | 27,698 | 264,161 |
| 16 | Ginning and textiles | 0 | 0 | 4,253,279 | 1,419,506 |
| 17 | Sawmills and wooden goods | 0 | 0 | 685,732 | 49,555 |
| 18 | Paper, printing, and publishing | 6,688 | 63 | 472,221 | 163,759 |
| 19 | Rubber and leather products | 0 | 0 | 716,475 | 465,347 |
| 20 | Basic chemicals, including fertilizers | 0 | 0 | 2,665,230 | 14,118 |
| 21 | Drugs and pharmaceuticals | 0 | 0 | 470,086 | 802,406 |
| 22 | Other chemicals | 0 | 0 | 259,541 | 656,391 |
| 23 | Glass and mineral products | 0 | 0 | 1,540,311 | 19,221 |
| 24 | Basic metal industries | 0 | 0 | 3,504,710 | 19,551 |
| 25 | Metal products | 0 | 0 | 1,134,305 | 50,021 |
| 26 | Machinery, except electrical | 0 | 0 | 91,658 | 38,779 |
| 27 | Electrical machinery | 0 | 21 | 114,616 | 52,336 |
| 28 | Railroad equipment | 0 | 0 | 60,704 | 0 |
| 29 | Motor vehicles, manufacture and repair | 0 | 22 | 136,640 | 0 |
| 30 | Bicycles and parts | 945 | 6 | 114.504 | 7,593 |
| 31 | Scientific and surgical instruments | 0 | 0 | 347,349 | 0 |
| 32 | Sports and athletic goods | 0 | 0 | 0 | 1,165 |
| 33 | Miscellaneous industries | 0 | 0 | 29,803 | 95,557 |
| 34 | Electricity, gas, and water supply | 4,799 | 380 | 1,034,551 | 186,288 |
| 35 | Construction | 0 | 0 | 0 | 16,868 |
| 36 | Trade, transport, and storage | 33,862 | 775 | 6,866,493 | 3,396,441 |
| 37 | Other services | 18,208 | 2,773 | 1,336,038 | 449,653 |
| 38 | Banking and insurance | 83,191 | 680 | 866,996 | 118,676 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 0 | 578,273 |
| 40 | Total inputs | 147,693 | 4,720 | 34,582,720 | 20,391,540 |
| 41 | Noncompetitive imports | 1,252 | 225 | 5,076,008 | 340,863 |
| 42 | Repair and maintenance | 0 | 0 | 746,936 | 0 |
| 43 | Work done by others | 0 | 0 | 780,782 | 0 |
| 44 | Taxes, duties, subsidy | 4,183 | 282 | 1,363,132 | 13,298 |
| 45 | Consumable stores | 0 | 0 | 578,930 | 0 |
| 46 | Depreciation | 33,700 | 274,300 | 2,494,259 | 0 |
| 47 | Net value added | 876,700 | 530,300 | 42,378,780 | 0 |
| 48 | Gross output | 1,063,528 | 809,827 | 88,001,550 | 20,745,710 |
| 49 | Workers (in number of persons) | 37,897 | 25,370 | 4,630,863 | 0 |
| 50 | Person-days (in thousands of days) | 10,611 | 8,372 | 1,282,319 | 0 |
| 51 | Wages | 457,900 | 106,060 | 19,301,160 | 0 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Urban Consumption (42) | Government Consumption (43) | Capital Formation (44) | Change in in Stocks (45) |
|---|---|---|---|---|---|
| | | (Rs 1,000) | | | |
| 1 | Wheat | 527,446 | 0 | 0 | 300,000 |
| 2 | Rice | 42,820 | 0 | 0 | 160,000 |
| 3 | Cotton | 0 | 0 | 0 | 0 |
| 4 | Sugarcane | 15,831 | 0 | 0 | 0 |
| 5 | Gram and pulses | 180,296 | 0 | 0 | 0 |
| 6 | Oilseeds | 0 | 0 | 0 | 0 |
| 7 | Other agriculture and forestry | 83,044 | 24,719 | 14,407 | 0 |
| 8 | Animal husbandry | 1,198,125 | 672 | 220,398 | 0 |
| 9 | Dairy products and confectionery | 220,604 | 0 | 0 | 27,100 |
| 10 | Grain mill products | 595,912 | 0 | 0 | 0 |
| 11 | Bakery products | 108,213 | 0 | 0 | 0 |
| 12 | Sugar | 238,334 | 0 | 0 | 0 |
| 13 | Other food industries | 56,905 | 0 | 0 | 0 |
| 14 | Edible oils | 357,951 | 0 | 0 | 72,000 |
| 15 | Breweries and beverages | 189,370 | 0 | 0 | 7,500 |
| 16 | Ginning and textiles | 402,516 | 17,506 | 0 | 74,350 |
| 17 | Sawmills and wooden goods | 8,111 | 642 | 3,464 | 900 |
| 18 | Paper, printing, and publishing | 100,134 | 2,962 | 0 | 1,400 |
| 19 | Rubber and leather products | 136,905 | 3,516 | 0 | 42,200 |
| 20 | Basic chemicals, including fertilizers | 0 | 4,248 | 0 | 1,600 |
| 21 | Drugs and pharmaceuticals | 354,399 | 0 | 0 | 0 |
| 22 | Other chemicals | 373,468 | 591 | 0 | 0 |
| 23 | Glass and mineral products | 2,871 | 782 | 0 | 39,600 |
| 24 | Basic metal industries | 0 | 14,989 | 0 | 0 |
| 25 | Metal products | 7,322 | 3,639 | 0 | 6,300 |
| 26 | Machinery, except electrical | 15,406 | 104,700 | 1,810,045 | 17,200 |
| 27 | Electrical machinery | 43,374 | 5,474 | 395,054 | 37,600 |
| 28 | Railroad equipment | 0 | 0 | 0 | 0 |
| 29 | Motor vehicles, manufacture and repair | 2,073 | 28 | 252,978 | 85,850 |
| 30 | Bicycles and parts | 5,603 | 0 | 0 | 0 |
| 31 | Scientific and surgical instruments | 0 | 14,443 | 0 | 0 |
| 32 | Sports and athletic goods | 1,366 | 0 | 0 | 0 |
| 33 | Miscellaneous industries | 10,827 | 7,024 | 0 | 8,000 |
| 34 | Electricity, gas, and water supply | 228,663 | 0 | 0 | 0 |
| 35 | Construction | 22,048 | 0 | 6,813,743 | 0 |
| 36 | Trade, transport, and storage | 1,000,401 | 79,370 | 323,838 | 0 |
| 37 | Other services | 459,349 | 0 | 0 | 0 |
| 38 | Banking and insurance | 48,477 | 0 | 0 | 0 |
| 39 | Real estate and ownership of dwellings | 231,554 | 0 | 0 | 0 |
| 40 | Total inputs | 8,017,118 | 285,305 | 9,833,927 | 881,600 |
| 41 | Noncompetitive imports | 444,905 | 79,016 | 0 | 329,600 |
| 42 | Repair and maintenance | 0 | 24,684 | 0 | 0 |
| 43 | Work done by others | 0 | 0 | 0 | 0 |
| 44 | Taxes, duties, subsidy | 7,077 | 0 | 626,702 | 0 |
| 45 | Consumable stores | 0 | 0 | 0 | 0 |
| 46 | Depreciation | 0 | 20,295 | 0 | 0 |
| 47 | Net value added | 0 | 0 | 0 | 0 |
| 48 | Gross output | 8,469,100 | 409,300 | 10,460,630 | 1,211,200 |
| 49 | Workers (in number of persons) | 0 | 0 | 0 | 0 |
| 50 | Person-days (in thousands of days) | 0 | 0 | 0 | 0 |
| 51 | Wages | 0 | 0 | 0 | 0 |

*(continued)*

## Table 44—Continued

| Sector Number | Sector | Exports (46) | Imports (47) | Final Demand (48) | Gross Output (49) |
|---|---|---|---|---|---|
| | | | (Rs 1,000) | | |
| 1 | Wheat | 5,593,841 | 833 | 7,808,083 | 9,734,551 |
| 2 | Rice | 4,491,654 | 148,903 | 4,770,875 | 5,188,749 |
| 3 | Cotton | 1,654,189 | 241,100 | 1,413,089 | 2,196,091 |
| 4 | Sugarcane | 146,124 | 39,534 | 639,576 | 813,451 |
| 5 | Gram and pulses | 0 | 432,475 | 255,965 | 478,604 |
| 6 | Oilseeds | 138,000 | 298,472 | −160,472 | 454,093 |
| 7 | Other agriculture and forestry | 486,200 | 1,265,016 | 1,989,913 | 2,944,243 |
| 8 | Animal husbandry | 2,350,675 | 217,700 | 6,777,774 | 7,975,900 |
| 9 | Dairy products and confectionery | 188,920 | 921,692 | 325,413 | 669,022 |
| 10 | Grain mill products | 200,411 | 489,157 | 1,807,820 | 1,873,985 |
| 11 | Bakery products | 112,156 | 151,571 | 146,761 | 155,682 |
| 12 | Sugar | 23,200 | 576,341 | 98,412 | 195,133 |
| 13 | Other food industries | 324,904 | 280,119 | 474,808 | 511,832 |
| 14 | Edible oils | 685,085 | 837,000 | 865,486 | 1,875,950 |
| 15 | Breweries and beverages | 0 | 203,993 | 257,038 | 284,736 |
| 16 | Ginning and textiles | 1,848,152 | 1,083,200 | 2,678,830 | 6,932,109 |
| 17 | Sawmills and wooden goods | 143,747 | 291,036 | −84,617 | 601,115 |
| 18 | Paper, printing, and publishing | 15,200 | 612,039 | −328,584 | 143,637 |
| 19 | Rubber and leather products | 210,200 | 684,409 | 173,759 | 890,234 |
| 20 | Basic chemicals, including fertilizers | 364,500 | 1,965,093 | −1,580,627 | 1,084,603 |
| 21 | Drugs and pharmaceuticals | 197,500 | 1,785,734 | −431,429 | 38,657 |
| 22 | Other chemicals | 3,655,088 | 4,711,600 | −26,062 | 233,479 |
| 23 | Glass and mineral products | 580,569 | 695,000 | −51,957 | 1,488,354 |
| 24 | Basic metal industries | 3,266,686 | 2,477,700 | 823,526 | 4,328,236 |
| 25 | Metal products | 227,592 | 51,805 | 243,069 | 1,377,374 |
| 26 | Machinery, except electrical | 261,000 | 1,219,766 | 1,027,364 | 1,119,022 |
| 27 | Electrical machinery | 437,705 | 550,370 | 421,173 | 535,789 |
| 28 | Railroad equipment | 4,510 | 0 | 4,510 | 65,214 |
| 29 | Motor vehicles, manufacture and repair | 710,696 | 115,400 | 936,225 | 1,072,865 |
| 30 | Bicycles and parts | 1,213,246 | 28,000 | 1,198,442 | 1,312,946 |
| 31 | Scientific and surgical instruments | 7,328 | 283,283 | −261,512 | 85,837 |
| 32 | Sports and athletic goods | 412,250 | 2,531 | 412,250 | 412,250 |
| 33 | Miscellaneous industries | 127,373 | 85,954 | 162,827 | 192,630 |
| 34 | Electricity, gas, and water supply | 451,669 | 243,873 | 622,747 | 1,657,298 |
| 35 | Construction | 0 | 0 | 6,852,659 | 6,852,659 |
| 36 | Trade, transport, and storage | 2,174,683 | 0 | 6,974,733 | 13,841,230 |
| 37 | Other services | 4,265,601 | 0 | 5,174,603 | 6,510,641 |
| 38 | Banking and insurance | 29,379 | 0 | 196,532 | 1,063,528 |
| 39 | Real estate and ownership of dwellings | 0 | 0 | 809,827 | 809,827 |
| 40 | Total inputs | 37,000,040 | 22,990,700 | 53,418,830 | 88,001,550 |
| 41 | Noncompetitive imports | 0 | 0 | 1,194,384 | 6,270,392 |
| 42 | Repair and maintenance | 0 | 0 | 24,684 | 771,620 |
| 43 | Work done by others | 0 | 0 | 0 | 780,782 |
| 44 | Taxes, duties, subsidy | 0 | 0 | 647,077 | 2,010,209 |
| 45 | Consumable stores | 0 | 0 | 0 | 578,930 |
| 46 | Depreciation | 0 | 0 | 20,295 | 2,514,554 |
| 47 | Net value added | 0 | 0 | 0 | 42,378,780 |
| 48 | Gross output | 37,000,040 | 22,990,700 | 55,305,270 | 143,306,800 |
| 49 | Workers (in number of persons) | 0 | 0 | 0 | 4,630,863 |
| 50 | Person-days (in thousands of days) | 0 | 0 | 0 | 1,282,319 |
| 51 | Wages | 0 | 0 | 0 | 19,301,160 |

Source:Constructed by the authors from sources described in Chapter 3.

## Table 45—Linkage analysis of Punjab's economy, without import leakages, 1969/70

| Sector Number | Sector | Z-Matrix | | | | Y-Matrix | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $U_i$ | $V_i$ | $U_j$ | $V_j$ | $U_i$ | $V_i$ | $U_j$ | $V_j$ |
| 1 | Wheat | 1.17 (9) | 4.20 | 0.83 (26) | 5.19 | 2.08 (5) | 4.20 | 1.45 (5) | 5.31 |
| 2 | Rice | 0.86 (15) | 5.14 | 0.84 (23) | 5.20 | 1.46 (6) | 5.14 | 1.39 (10) | 5.32 |
| 3 | Maize | 0.72 (27) | 5.94 | 0.83 (28) | 5.16 | 1.24 (8) | 5.94 | 1.40 (9) | 5.25 |
| 4 | Cotton | 0.74 (23) | 5.72 | 0.84 (25) | 5.06 | 1.17 (11) | 5.72 | 1.26 (13) | 5.29 |
| 5 | Sugarcane | 1.24 (7) | 4.16 | 0.94 (18) | 5.08 | 1.92 (5) | 4.16 | 1.46 (2) | 5.04 |
| 6 | Gram and pulses | 0.81 (18) | 5.50 | 0.86 (22) | 5.20 | 1.35 (7) | 5.50 | 1.44 (6) | 5.20 |
| 7 | Oilseeds | 1.60 (5) | 3.36 | 0.87 (21) | 5.12 | 2.58 (3) | 3.36 | 1.41 (8) | 5.09 |
| 8 | Bajra | 0.71 (29) | 6.00 | 0.83 (27) | 5.12 | 1.21 (9) | 6.00 | 1.43 (7) | 5.12 |
| 9 | Other agriculture and forestry | 1.80 (4) | 2.83 | 0.83 (29) | 5.33 | 3.36 (2) | 2.83 | 1.52 (1) | 5.38 |
| 10 | Animal husbandry | 2.03 (2) | 2.18 | 0.84 (24) | 5.07 | 3.61 (1) | 2.18 | 1.46 (4) | 5.27 |
| 11 | Dairy products | 0.76 (20) | 5.94 | 1.29 (5) | 3.66 | 0.09 (33) | 5.94 | 0.77 (23) | 3.75 |
| 12 | Grain mill products | 0.73 (25) | 5.79 | 1.42 (1) | 3.40 | 0.14 (31) | 5.79 | 1.38 (11) | 3.33 |
| 13 | Sugar and confectionery | 0.98 (12) | 4.97 | 1.29 (4) | 4.11 | 0.29 (27) | 4.97 | 0.97 (19) | 3.87 |
| 14 | Edible oils and other food-processing industries | 0.78 (19) | 5.78 | 1.32 (2) | 3.55 | 0.26 (28) | 5.78 | 1.01 (18) | 2.84 |
| 15 | Breweries and beverages | 0.71 (28) | 6.00 | 1.17 (8) | 3.85 | 0.23 (29) | 6.00 | 0.54 (33) | 3.17 |
| 16 | Textiles | 1.14 (10) | 5.18 | 1.11 (13) | 5.29 | 0.64 (17) | 5.18 | 0.68 (28) | 4.87 |
| 17 | Cotton ginning, pressing, and other textiles | 0.89 (14) | 4.74 | 1.32 (3) | 3.86 | 0.10 (32) | 4.74 | 1.08 (16) | 4.50 |
| 18 | Sawmills and wooden containers | 0.74 (24) | 5.79 | 1.21 (7) | 4.05 | 0.46 (24) | 5.79 | 1.34 (12) | 3.97 |
| 19 | Furniture and fixtures | 0.70 (31) | 5.99 | 1.13 (10) | 3.95 | 0.54 (20) | 5.99 | 1.14 (15) | 3.76 |
| 20 | Printing and publishing | 0.70 (31) | 5.99 | 0.80 (32) | 5.23 | 0.59 (19) | 5.99 | 0.71 (27) | 4.98 |
| 21 | Rubber and leather products | 1.07 (11) | 5.01 | 0.05 (36) | 5.06 | 0.70 (15) | 5.01 | 0.75 (25) | 4.66 |
| 22 | Basic chemicals, including fertilizers | 1.27 (6) | 3.40 | 0.92 (19) | 4.72 | 1.20 (10) | 3.40 | 0.98 (22) | 4.40 |
| 23 | Other chemicals | 0.93 (13) | 4.78 | 0.98 (17) | 4.57 | 0.41 (25) | 4.78 | 0.56 (32) | 3.74 |
| 24 | Glass and mineral products | 1.95 (3) | 3.95 | 1.25 (6) | 5.92 | 1.20 (10) | 3.95 | 0.79 (21) | 5.79 |
| 25 | Basic metal industries | 2.32 (1) | 2.69 | .00 (16) | 5.85 | 0.70 (14) | 2.69 | 0.33 (35) | 5.36 |
| 26 | Metal products | 0.86 (16) | 4.93 | 1.03 (15) | 4.39 | 0.50 (21) | 4.93 | 0.57 (31) | 4.67 |
| 27 | Machinery, except electrical | 0.74 (22) | 5.88 | 0.81 (31) | 5.41 | 0.18 (30) | 5.88 | 0.24 (36) | 4.38 |
| 28 | Electrical machinery | 0.72 (26) | 5.96 | 1.13 (12) | 4.11 | 0.33 (26) | 5.96 | 0.52 (34) | 3.86 |
| 29 | Railroad equipment | 0.70 (32) | 6.00 | 0.77 (33) | 5.45 | 1.14 (12) | 6.00 | 1.19 (14) | 5.72 |
| 30 | Transport equipment | 0.76 (21) | 5.63 | 0.90 (20) | 4.73 | 0.54 (21) | 5.63 | 0.63 (29) | 4.73 |
| 31 | Repair of transport equipment | 0.70 (32) | 6.00 | 0.82 (30) | 5.11 | 0.65 (16) | 6.00 | 0.73 (26) | 5.28 |
| 32 | Motorcycles and bicycles | 0.83 (17) | 6.00 | 1.14 (9) | 4.48 | 0.48 (22) | 6.00 | 0.62 (30) | 4.60 |
| 33 | Scientific and surgical instruments | 0.70 (30) | 6.00 | 0.77 (34) | 5.48 | 0.99 (13) | 6.00 | 1.04 (17) | 5.68 |
| 34 | Miscellaneous industries | 0.74 (24) | 5.84 | 1.04 (14) | 4.13 | 0.47 (23) | 5.84 | 0.77 (24) | 3.57 |
| 35 | Construction | 0.70 (32) | 6.00 | 1.13 (11) | 4.00 | 0.63 (10) | 6.00 | 0.96 (20) | 4.10 |
| 36 | Electricity | 1.24 (8) | 3.52 | 0.73 (35) | 6.00 | 2.47 (4) | 3.52 | 1.46 (3) | 6.00 |

*(continued)*

## Table 45—Continued

| Sector Number | Sector | W-Matrix | | | | N-Matrix | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $U_i$ | $V_i$ | $U_j$ | $V_j$ | $U_i$ | $V_i$ | $U_j$ | $V_j$ |
| 1 | Wheat | 1.70 (5) | 4.20 | 1.18 (16) | 5.36 | 0.37 (23) | 4.20 | 0.38 (26) | 4.01 |
| 2 | Rice | 0.15 (33) | 5.14 | 0.24 (36) | 3.67 | 0.30 (25) | 5.14 | 0.44 (23) | 3.97 |
| 3 | Maize | 1.44 (9) | 5.94 | 1.56 (4) | 5.48 | 0.16 (33) | 5.94 | 0.30 (29) | 3.72 |
| 4 | Cotton | 1.32 (11) | 5.72 | 1.37 (8) | 5.52 | 0.06 (35) | 5.72 | 0.23 (32) | 3.02 |
| 5 | Sugarcane | 2.41 (4) | 4.16 | 1.74 (2) | 5.30 | 0.18 (32) | 4.16 | 0.22 (33) | 3.55 |
| 6 | Gram and pulses | 1.16 (12) | 5.50 | 1.24 (12) | 5.17 | 0.21 (31) | 5.50 | 0.25 (31) | 4.66 |
| 7 | Oilseeds | 2.29 (3) | 3.36 | 1.24 (11) | 5.13 | 0.26 (28) | 3.36 | 0.20 (34) | 3.78 |
| 8 | Bajra | 0.99 (16) | 6.00 | 1.18 (14) | 5.05 | 0.12 (34) | 6.00 | 0.16 (36) | 4.41 |
| 9 | Other agriculture and forestry | 3.45 (1) | 2.83 | 1.54 (5) | 5.47 | 0.28 (26) | 2.83 | 0.16 (35) | 4.19 |
| 10 | Animal husbandry | 3.34 (2) | 2.18 | 1.33 (9) | 5.25 | 0.46 (17) | 2.18 | 0.25 (30) | 4.06 |
| 11 | Dairy products | 0.09 (35) | 5.94 | 0.75 (24) | 3.52 | 5.46 (1) | 5.94 | 5.72 (1) | 5.67 |
| 12 | Grain mill products | 0.07 (36) | 5.79 | 0.95 (19) | 3.84 | 2.47 (5) | 5.79 | 2.70 (4) | 5.29 |
| 13 | Sugar and confectionery | 0.45 (25) | 4.97 | 1.23 (13) | 3.96 | 1.08 (8) | 4.97 | 1.05 (11) | 5.10 |
| 14 | Edible oils and other food-processing industries | 0.19 (32) | 5.78 | 0.87 (21) | 2.78 | 0.89 (12) | 5.78 | 1.25 (10) | 4.15 |
| 15 | Breweries and beverages | 0.30 (20) | 6.00 | 0.67 (28) | 3.31 | 0.43 (20) | 6.00 | 0.74 (15) | 3.62 |
| 16 | Textiles | 0.85 (17) | 5.18 | 0.83 (23) | 5.28 | 0.77 (13) | 5.18 | 0.86 (14) | 4.71 |
| 17 | Cotton ginning, pressing, and other textiles | 0.12 (34) | 4.74 | 0.97 (18) | 4.43 | 2.18 (6) | 4.74 | 1.87 (5) | 5.54 |
| 18 | Sawmills and wooden containers | 0.53 (24) | 5.79 | 1.41 (7) | 4.00 | 0.45 (18) | 5.79 | 0.55 (20) | 4.75 |
| 19 | Furniture and fixtures | 0.63 (21) | 5.99 | 1.24 (10) | 3.82 | 2.71 (14) | 5.99 | 2.98 (2) | 5.46 |
| 20 | Printing and publishing | 1.12 (14) | 5.99 | 1.18 (15) | 5.61 | 0.21 (31) | 5.99 | 0.41 (24) | 3.72 |
| 21 | Rubber and leather products | 0.74 (19) | 5.01 | 0.74 (25) | 5.02 | 0.41 (21) | 5.01 | 0.60 (17) | 3.81 |
| 22 | Basic chemicals, including fertilizers | 0.39 (27) | 3.40 | 0.38 (34) | 3.90 | 4.51 (2) | 3.40 | 2.76 (3) | 5.57 |
| 23 | Other chemicals | 0.22 (31) | 4.78 | 0.31 (35) | 3.57 | 1.49 (7) | 4.78 | 1.73 (6) | 4.38 |
| 24 | Glass and mineral products | 1.65 (6) | 3.95 | 1.06 (17) | 5.92 | 0.74 (14) | 3.95 | 0.49 (22) | 5.76 |
| 25 | Basic metal industries | 0.99 (5) | 2.69 | 0.43 (23) | 5.71 | 3.79 (3) | 2.69 | 1.61 (7) | 5.91 |
| 26 | Metal products | 0.68 (20) | 4.93 | 0.71 (26) | 5.83 | 0.45 (19) | 4.93 | 0.90 (12) | 3.[illegible]1 |
| 27 | Machinery, except electrical | 0.56 (23) | 5.88 | 0.61 (29) | 5.40 | 0.53 (16) | 5.88 | 0.60 (19) | 5.20 |
| 28 | Electrical machinery | 0.30 (30) | 5.96 | 0.51 (31) | 3.76 | 0.90 (11) | 5.96 | 1.52 (8) | 4.00 |
| 29 | Railroad equipment | 1.52 (8) | 6.00 | 1.56 (3) | 5.85 | 0.30 (24) | 6.00 | 0.41 (25) | 4.55 |
| 30 | Transport equipment | 0.43 (26) | 5.63 | 0.54 (30) | 4.52 | 0.70 (15) | 5.63 | 0.90 (13) | 4.49 |
| 31 | Repair of transport equipment | 1.39 (10) | 6.00 | 1.46 (6) | 5.70 | 0.24 (30) | 6.00 | 0.37 (27) | 3.94 |
| 32 | Motorcycles and bicycles | 0.32 (28) | 6.00 | 0.48 (32) | 4.14 | 0.94 (10) | 6.00 | 0.38 (9) | 4.32 |
| 33 | Scientific and surgical instruments | 0.80 (18) | 6.00 | 0.85 (22) | 5.60 | 0.25 (29) | 6.00 | 0.32 (28) | 4.77 |
| 34 | Miscellaneous industries | 0.63 (22) | 5.84 | 0.92 (20) | 4.03 | 0.37 (22) | 5.84 | 0.60 (18) | 3.68 |
| 35 | Construction | 1.64 (7) | 6.00 | 2.04 (1) | 4.85 | 0.27 (27) | 6.00 | 0.50 (21) | 3.64 |
| 36 | Electricity | 1.14 (13) | 3.52 | 0.67 (27) | 6.00 | 1.07 (9) | 3.52 | 0.63 (16) | 6.00 |

Source: Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980), App. 2.9, 211-215.

Note: Figures in parentheses indicate rank.

## Table 46—Linkage analysis of Punjab's economy, with import leakages, 1969/70

| Sector Number | Sector | R-Matrix $U_i$ | R-Matrix $V_i$ | R-Matrix $U_j$ | R-Matrix $V_j$ | W'-Matrix $U_i$ | W'-Matrix $V_i$ | W'-Matrix $U_j$ | W'-Matrix $V_j$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Wheat | 1.49 (3) | 4.22 | 1.04 (16) | 5.32 | 2.08 (4) | 4.22 | 1.43 (11) | 5.42 |
| 2 | Rice | 1.09 (7) | 5.14 | 1.04 (17) | 5.36 | 0.19 (31) | 5.14 | 0.27 (32) | 3.87 |
| 3 | Maize | 0.92 (17) | 5.95 | 1.03 (18) | 5.29 | 1.76 (6) | 5.95 | 1.90 (4) | 5.57 |
| 4 | Cotton | 0.91 (18) | 5.75 | 0.97 (24) | 5.39 | 1.56 (8) | 5.75 | 1.60 (6) | 5.60 |
| 5 | Sugarcane | 1.18 (6) | 5.07 | 1.16 (13) | 5.16 | 2.20 (3) | 5.07 | 2.07 (2) | 5.34 |
| 6 | Gram and pulses | 0.97 (14) | 5.55 | 1.03 (19) | 5.25 | 1.33 (9) | 5.55 | 1.43 (10) | 5.21 |
| 7 | Oilseeds | 0.85 (25) | 3.45 | 0.48 (33) | 0.17 | 1.17 (12) | 3.45 | 0.66 (23) | 5.16 |
| 8 | Bajra | 0.91 (15) | 6.00 | 1.06 (15) | 5.16 | 1.21 (10) | 6.00 | 1.44 (8) | 5.09 |
| 9 | Other agriculture and forestry | 1.67 (2) | 2.88 | 0.78 (27) | 5.26 | 3.07 (2) | 2.88 | 1.39 (12) | 5.49 |
| 10 | Animal husbandry | 2.29 (1) | 2.46 | 1.02 (20) | 5.25 | 3.60 (1) | 2.46 | 1.56 (7) | 5.42 |
| 11 | Dairy products | 0.97 (12) | 5.97 | 1.52 (2) | 3.97 | 0.11 (33) | 5.97 | 0.82 (19) | 3.91 |
| 12 | Grain mill products | 0.93 (16) | 5.82 | 1.76 (1) | 3.52 | 0.09 (34) | 5.82 | 1.09 (8) | 4.05 |
| 13 | Sugar and confectionery | 0.43 (29) | 5.32 | 0.59 (31) | 4.18 | 0.19 (29) | 5.32 | 0.53 (28) | 3.99 |
| 14 | Edible oils and other food-processing industries | 0.85 (24) | 5.90 | 1.22 (8) | 4.12 | 0.20 (28) | 5.90 | 0.61 (34) | 2.53 |
| 15 | Breweries and beverages | 0.16 (31) | 6.00 | 0.22 (35) | 4.53 | 0.07 (36) | 6.00 | 0.11 (33) | 3.88 |
| 16 | Textiles | 0.14 (32) | 5.29 | 1.37 (4) | 5.46 | 1.01 (14) | 5.29 | 0.97 (16) | 5.54 |
| 17 | Cotton ginning, pressing, and other textiles | 1.08 (9) | 4.84 | 1.22 (9) | 4.45 | 0.14 (32) | 4.84 | 0.58 (26) | 3.90 |
| 18 | Sawmills and wooden containers | 0.94 (16) | 5.81 | 1.38 (3) | 4.27 | 0.65 (21) | 5.81 | 1.44 (9) | 3.94 |
| 19 | Furniture and fixtures | 0.90 (21) | 6.00 | 1.27 (6) | 4.36 | 0.78 (17) | 6.00 | 1.32 (13) | 4.04 |
| 20 | Printing and publishing | 0.52 (11) | 6.00 | 0.58 (32) | 5.39 | 0.80 (18) | 6.00 | 0.84 (17) | 5.73 |
| 21 | Rubber and leather products | 1.04 (28) | 5.03 | 1.00 (22) | 5.21 | 0.70 (20) | 5.03 | 0.68 (22) | 5.13 |
| 22 | Basic chemicals, including fertilizers | 0.89 (23) | 3.90 | 0.72 (29) | 4.95 | 0.26 (27) | 3.90 | 0.28 (31) | 4.10 |
| 23 | Other chemicals | 0.35 (30) | 5.00 | 0.35 (34) | 4.97 | 0.08 (35) | 5.00 | 0.10 (34) | 4.13 |
| 24 | Glass and mineral products | 1.31 (5) | 4.57 | 0.99 (23) | 5.93 | 1.06 (13) | 4.57 | 0.80 (20) | 5.93 |
| 25 | Basic metal industries | 1.47 (4) | 2.78 | 0.65 (30) | 5.87 | 0.60 (22) | 2.78 | 0.27 (32) | 5.74 |
| 26 | Metal products | 1.08 (8) | 5.00 | 1.12 (11) | 4.91 | 0.82 (16) | 5.00 | 0.78 (21) | 5.27 |
| 27 | Machinery, except electrical | 0.69 (27) | 5.93 | 0.74 (28) | 5.55 | 0.50 (24) | 5.93 | 0.50 (27) | 5.51 |
| 28 | Electrical machinery | 0.81 (26) | 5.96 | 1.06 (14) | 4.64 | 0.32 (26) | 5.96 | 0.45 (30) | 4.28 |
| 29 | Railroad equipment | 0.89 (22) | 6.00 | 0.95 (25) | 5.62 | 0.19 (30) | 6.00 | 1.91 (3) | 5.89 |
| 30 | Transport equipment | 0.97 (13) | 5.63 | 1.07 (12) | 5.12 | 0.53 (23) | 5.63 | 0.60 (25) | 4.88 |
| 31 | Repair of transport equipment | 0.89 (22) | 6.00 | 1.01 (21) | 5.29 | 1.71 (7) | 6.00 | 1.78 (5) | 5.75 |
| 32 | Motorcycles and bicycles | 1.06 (10) | 6.00 | 1.29 (5) | 4.96 | 0.39 (25) | 6.00 | 0.51 (29) | 4.63 |
| 33 | Scientific and surgical instruments | 0.90 (20) | 6.00 | 0.95 (25) | 5.65 | 0.98 (15) | 6.00 | 1.03 (15) | 5.72 |
| 34 | Miscellaneous industries | 0.91 (19) | 5.87 | 1.21 (10) | 4.12 | 0.75 (19) | 5.87 | 1.03 (14) | 4.20 |
| 35 | Construction | 0.89 (22) | 6.00 | 1.24 (7) | 4.46 | 1.82 (5) | 6.00 | 2.33 (1) | 6.00 |
| 36 | Electricity | 0.14 (33) | 4.09 | 0.94 (26) | 6.00 | 1.21 (11) | 4.09 | 0.83 (18) | 6.00 |

*(continued)*

## Table 46—Continued

| Sector Number | Sector | Z-Matrix | | | | Y-Matrix | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $U_i$ | $V_i$ | $U_j$ | $V_j$ | $U_i$ | $V_i$ | $U_j$ | $V_j$ |
| 1 | Wheat | 2.53 (4) | 4.22 | 1.75 (2) | 5.40 | 0.47 (19) | 4.22 | 0.42 (23) | 4.34 |
| 2 | Rice | 1.77 (5) | 5.14 | 1.66 (7) | 5.43 | 0.37 (24) | 5.14 | 0.47 (21) | 4.28 |
| 3 | Maize | 1.51 (8) | 5.95 | 1.68 (6) | 5.33 | 0.20 (30) | 5.95 | 0.32 (27) | 4.00 |
| 4 | Cotton | 1.38 (11) | 5.75 | 1.46 (10) | 5.45 | 0.07 (36) | 5.75 | 0.17 (33) | 3.09 |
| 5 | Sugarcane | 1.75 (6) | 5.07 | 1.73 (4) | 5.11 | 0.17 (31) | 5.07 | 0.24 (31) | 3.78 |
| 6 | Gram and pulses | 1.55 (7) | 5.55 | 1.65 (8) | 5.24 | 0.25 (29) | 5.55 | 0.28 (29) | 4.85 |
| 7 | Oilseeds | 1.31 (12) | 3.45 | 0.79 (22) | 5.13 | 0.14 (34) | 3.45 | 0.10 (36) | 4.02 |
| 8 | Bajra | 1.49 (9) | 6.00 | 1.74 (3) | 5.15 | 0.15 (33) | 6.00 | 0.20 (32) | 4.51 |
| 9 | Other agriculture and forestry | 2.98 (2) | 2.88 | 1.37 (12) | 5.41 | 0.26 (28) | 2.88 | 0.14 (34) | 4.42 |
| 10 | Animal husbandry | 3.95 (1) | 2.46 | 1.71 (5) | 5.44 | 0.51 (16) | 2.46 | 0.31 (28) | 4.20 |
| 11 | Dairy products | 0.11 (34) | 5.97 | 0.85 (18) | 4.09 | 6.92 (1) | 5.97 | 7.15 (1) | 5.77 |
| 12 | Grain mill products | 0.17 (30) | 5.82 | 1.60 (9) | 3.49 | 3.13 (4) | 5.82 | 3.38 (3) | 5.39 |
| 13 | Sugar and confectionery | 0.12 (33) | 5.32 | 0.42 (31) | 3.92 | 0.46 (20) | 5.32 | 0.47 (20) | 5.20 |
| 14 | Edible oils and other food-processing industries | 0.28 (29) | 5.90 | 0.73 (23) | 2.70 | 0.97 (10) | 5.90 | 1.28 (8) | 4.47 |
| 15 | Breweries and beverages | 0.05 (36) | 6.00 | 0.09 (34) | 3.76 | 0.10 (35) | 6.00 | 0.13 (35) | 4.46 |
| 16 | Textiles | 0.75 (18) | 5.29 | 0.77 (20) | 5.22 | 0.95 (11) | 5.29 | 1.05 (9) | 4.87 |
| 17 | Cotton ginning, pressing, and other textiles | 0.11 (35) | 4.84 | 0.63 (27) | 4.00 | 2.62 (5) | 4.84 | 2.19 (4) | 5.79 |
| 18 | Sawmills and wooden containers | 0.56 (24) | 5.81 | 1.36 (13) | 3.89 | 0.87 (13) | 5.81 | 0.66 (15) | 5.06 |
| 19 | Furniture and fixtures | 0.67 (11) | 6.00 | 1.19 (15) | 3.94 | 3.45 (2) | 6.00 | 3.64 (2) | 5.68 |
| 20 | Printing and publishing | 0.42 (27) | 6.00 | 0.49 (29) | 5.14 | 0.15 (32) | 6.00 | 0.26 (30) | 3.92 |
| 21 | Rubber and leather products | 0.65 (21) | 5.03 | 0.67 (25) | 4.87 | 0.40 (22) | 5.03 | 0.52 (18) | 4.09 |
| 22 | Basic chemicals, including fertilizers | 0.81 (4) | 3.90 | 0.74 (21) | 4.51 | 3.15 (3) | 3.90 | 2.18 (5) | 5.69 |
| 23 | Other chemicals | 0.15 (32) | 5.00 | 0.18 (33) | 4.23 | 0.55 (15) | 5.00 | 0.60 (16) | 4.74 |
| 24 | Glass and mineral products | 0.77 (17) | 4.57 | 0.59 (28) | 5.80 | 0.49 (17) | 4.57 | 0.38 (25) | 5.81 |
| 25 | Basic metal industries | 0.43 (26) | 2.78 | 0.21 (32) | 5.39 | 2.37 (6) | 2.78 | 1.09 (10) | 5.93 |
| 26 | Metal products | 0.65 (22) | 5.00 | 0.63 (26) | 5.12 | 0.56 (14) | 5.00 | 0.82 (12) | 4.03 |
| 27 | Machinery, except electrical | 0.16 (31) | 5.93 | 0.21 (32) | 4.61 | 0.49 (18) | 5.93 | 0.53 (17) | 5.47 |
| 28 | Electrical machinery | 0.35 (28) | 5.96 | 0.46 (30) | 4.42 | 1.01 (9) | 5.96 | 1.37 (7) | 4.51 |
| 29 | Railroad equipment | 1.40 (16) | 6.00 | 1.45 (11) | 5.77 | 0.39 (23) | 6.00 | 0.97 (22) | 4.99 |
| 30 | Transport equipment | 0.66 (20) | 5.63 | 0.73 (23) | 5.04 | 0.89 (12) | 5.63 | 1.00 (11) | 5.02 |
| 31 | Repair of transport equipment | 0.79 (15) | 6.00 | 0.88 (17) | 5.34 | 0.30 (27) | 6.00 | 0.42 (24) | 4.41 |
| 32 | Motorcycles and bicycles | 0.59 (23) | 6.00 | 0.70 (24) | 5.01 | 1.20 (7) | 6.00 | 1.50 (6) | 4.85 |
| 33 | Scientific and surgical instruments | 1.21 (13) | 6.00 | 1.26 (14) | 5.77 | 0.32 (26) | 6.00 | 0.37 (26) | 5.21 |
| 34 | Miscellaneous industries | 0.55 (25) | 5.87 | 0.85 (19) | 3.86 | 0.46 (20) | 5.87 | 0.66 (14) | 4.09 |
| 35 | Construction | 0.77 (16) | 6.00 | 1.03 (16) | 4.54 | 0.34 (25) | 6.00 | 0.51 (19) | 4.19 |
| 36 | Electricity | 2.61 (3) | 4.09 | 1.79 (1) | 6.00 | 1.17 (8) | 4.09 | 0.80 (13) | 6.00 |

Source: Y. K. Alagh, G. S. Bhalla, and S. P. Kashyap, *Structural Analysis of Gujarat, Punjab, and Haryana Economies—An Input-Output Study* (New Delhi: Allied, 1980), App. 2.10, 216-220.

Note: Figures in parentheses indicate rank.

## Table 47—Linkage analysis of Punjab's economy, without import leakages, 1979/80

| Sector Number | Sector | Z-Matrix $U_i$ | Z-Matrix $V_i$ | Z-Matrix $U_j$ | Z-Matrix $V_j$ | Y-Matrix $U_i$ | Y-Matrix $V_i$ | Y-Matrix $U_j$ | Y-Matrix $V_j$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Wheat | 1.15 (11) | 3.66 | 0.74 (29) | 4.82 | 1.59 (7) | 3.66 | 0.96 (25) | 5.09 |
| 2 | Rice | 0.63 (26) | 5.55 | 0.69 (30) | 5.06 | 1.07 (14) | 5.55 | 1.09 (17) | 5.48 |
| 3 | Cotton | 0.75 (23) | 4.71 | 0.68 (31) | 5.12 | 1.33 (9) | 4.71 | 1.12 (14) | 5.51 |
| 4 | Sugarcane | 1.07 (14) | 3.87 | 0.65 (34) | 5.45 | 2.13 (5) | 3.87 | 1.23 (3) | 5.74 |
| 5 | Gram and pulses | 0.63 (27) | 5.72 | 0.63 (36) | 5.70 | 1.18 (11) | 5.72 | 1.17 (7) | 5.81 |
| 6 | Oilseeds | 0.96 (17) | 3.98 | 0.64 (35) | 5.41 | 1.92 (6) | 3.98 | 1,.21 (4) | 5.70 |
| 7 | Other agriculture and forestry | 1.13 (12) | 3.23 | 0.59 (37) | 6.00 | 2.32 (3) | 3.23 | 1.20 (5) | 6.10 |
| 8 | Animal husbandry | 1.34 (8) | 2.66 | 0.84 (26) | 4.16 | 2.34 (2) | 2.66 | 1.27 (2) | 4.76 |
| 9 | Dairy products and confectionery | 0.83 (19) | 4.45 | 1.20 (11) | 3.24 | 0.48 (26) | 4.45 | 1.04 (19) | 2.83 |
| 10 | Grain mill products | 0.75 (22) | 4.71 | 1.17 (15) | 3.51 | 0.16 (39) | 4.71 | 0.96 (24) | 3.47 |
| 11 | Bakery products | 0.55 (36) | 6.23 | 1.24 (8) | 2.87 | 0.47 (27) | 6.23 | 1.13 (12) | 2.70 |
| 12 | Sugar | 0.76 (21) | 4.55 | 1.03 (24) | 3.94 | 0.33 (33) | 4.55 | 1.10 (16) | 4.22 |
| 13 | Other food industries | 0.60 (31) | 5.80 | 1.08 (21) | 3.32 | 0.41 (30) | 5.80 | 1.13 (10) | 2.74 |
| 14 | Edible oils | 1.12 (13) | 4.93 | 1.43 (1) | 4.00 | 0.21 (38) | 4.93 | 1.02 (20) | 3.54 |
| 15 | Breweries and beverages | 0.61 (29) | 6.21 | 1.25 (5) | 3.06 | 0.25 (37) | 6.21 | 0.50 (21) | 2.04 |
| 16 | Ginning and textiles | 1.59 (3) | 4.19 | 1.37 (2) | 4.88 | 0.71 (21) | 4.19 | 0.93 (29) | 3.49 |
| 17 | Sawmills and wooden goods | 1.19 (9) | 4.42 | 1.16 (16) | 4.54 | 1.15 (12) | 4.42 | 1.13 (11) | 4.53 |
| 18 | Paper, printing, and publishing | 1.15 (10) | 4.23 | 1.18 (14) | 4.17 | 1.01 (16) | 4.23 | 1.06 (18) | 4.13 |
| 19 | Rubber and leather products | 1.35 (6) | 3.84 | 1.19 (12) | 4.24 | 0.88 (19) | 3.84 | 0.95 (27) | 3.58 |
| 20 | Basic chemicals, including fertilizers | 1.50 (4) | 2.47 | 0.75 (28) | 4.89 | 0.93 (17) | 2.47 | 0.58 (38) | 4.01 |
| 21 | Drugs and pharmaceuticals | 0.71 (24) | 5.49 | 1.27 (3) | 3.09 | 0.30 (36) | 5.49 | 0.94 (28) | 2.10 |
| 22 | Other chemicals | 0.92 (18) | 4.59 | 1.25 (7) | 3.43 | 0.35 (31) | 4.59 | 0.96 (23) | 2.31 |
| 23 | Glass and mineral products | 1.35 (7) | 4.48 | 1.25 (4) | 4.79 | 1.26 (10) | 4.48 | 1.18 (6) | 4.79 |
| 24 | Basic metal industries | 3.21 (1) | 1.86 | 1.14 (18) | 4.27 | 0.72 (20) | 1.86 | 0.53 (39) | 2.76 |
| 25 | Metal products | 1.39 (5) | 2.83 | 1.24 (9) | 3.63 | 0.70 (22) | 2.83 | 0.70 (36) | 3.21 |
| 26 | Machinery, except electrical | 0.61 (30) | 5.80 | 1.15 (17) | 3.44 | 0.32 (34) | 5.80 | 0.68 (37) | 3.11 |
| 27 | Electrical machinery | 0.62 (28) | 5.61 | 1.22 (10) | 3.18 | 0.32 (35) | 5.61 | 0.73 (35) | 2.81 |
| 28 | Railroad equipment | 0.60 (32) | 6.11 | 1.03 (23) | 3.67 | 0.65 (23) | 6.11 | 0.96 (26) | 4.14 |
| 29 | Motor vehicles, manufacture and repair | 0.59 (34) | 5.97 | 1.05 (22) | 3.61 | 0.54 (24) | 5.97 | 0.84 (32) | 3.92 |
| 30 | Bicycles and parts | 0.59 (35) | 6.07 | 1.19 (13) | 3.24 | 0.46 (28) | 6.07 | 0.87 (31) | 3.32 |
| 31 | Scientific and surgical instruments | 0.64 (25) | 5.78 | 1.13 (19) | 3.49 | 0.45 (29) | 5.78 | 0.81 (34) | 3.38 |
| 32 | Sports and athletic goods | 0.55 (38) | 6.24 | 1.25 (6) | 2.96 | 0.34 (32) | 6.24 | 0.96 (22) | 2.45 |
| 33 | Miscellaneous industries | 0.59 (33) | 5.83 | 0.68 (32) | 5.10 | 1.01 (15) | 5.83 | 1.11 (15) | 5.33 |
| 34 | Electricity, gas, and water supply | 1.03 (16) | 3.39 | 0.59 (38) | 6.07 | 1.46 (8) | 3.39 | 0.83 (33) | 6.06 |
| 35 | Construction | 0.55 (38) | 6.24 | 1.12 (20) | 3.30 | 0.48 (25) | 6.24 | 1.12 (13) | 3.25 |
| 36 | Trade, transport, and storage | 2.97 (2) | 1.32 | 0.78 (27) | 5.01 | 4.61 (1) | 1.32 | 1.14 (9) | 5.30 |
| 37 | Other services | 0.82 (20) | 4.43 | 0.95 (25) | 3.88 | 1.10 (13) | 4.43 | 1.15 (8) | 4.27 |
| 38 | Banking and insurance | 1.06 (15) | 3.48 | 0.65 (33) | 5.70 | 2.17 (4) | 3.48 | 1.29 (1) | 5.90 |
| 39 | Real estate and ownership of dwellings | 0.55 (38) | 6.24 | 0.56 (39) | 6.19 | 0.89 (18) | 6.24 | 0.90 (30) | 6.20 |

*(continued)*

## Table 47—Continued

| Sector Number | Sector | W-Matrix |  |  |  | N-Matrix |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | $U_i$ | $V_i$ | $U_j$ | $V_j$ | $U_i$ | $V_i$ | $U_j$ | $V_j$ |
| 1 | Wheat | 0.93 (14) | 3.66 | 0.61 (36) | 4.65 | 1.52 (11) | 3.66 | 0.86 (24) | 5.43 |
| 2 | Rice | 0.80 (20) | 5.55 | 0.83 (24) | 5.35 | 1.59 (9) | 5.55 | 1.49 (7) | 5.93 |
| 3 | Cotton | 0.91 (15) | 4.71 | 0.79 (26) | 5.34 | 1.79 (8) | 4.71 | 1.43 (8) | 5.81 |
| 4 | Sugarcane | 1.14 (9) | 3.87 | 0.69 (33) | 5.50 | 2.17 (4) | 3.87 | 1.24 (11) | 5.80 |
| 5 | Gram and pulses | 0.75 (21) | 5.72 | 0.76 (29) | 5.66 | 1.53 (10) | 5.72 | 1.50 (6) | 5.84 |
| 6 | Oilseeds | 0.71 (24) | 3.98 | 0.50 (37) | 5.17 | 1.23 (14) | 3.98 | 0.82 (25) | 5.46 |
| 7 | Other agriculture and forestry | 1.39 (7) | 3.23 | 0.72 (32) | 6.04 | 2.75 (3) | 3.23 | 1.41 (9) | 6.13 |
| 8 | Animal husbandry | 1.66 (6) | 2.66 | 0.94 (19) | 4.56 | 3.27 (1) | 2.66 | 1.68 (3) | 5.04 |
| 9 | Dairy products and confectionery | 0.19 (38) | 4.45 | 0.79 (27) | 2.43 | 0.15 (37) | 4.45 | 0.94 (19) | 3.17 |
| 10 | Grain mill products | 0.20 (36) | 4.71 | 0.78 (28) | 2.84 | 0.23 (32) | 4.71 | 0.92 (20) | 3.51 |
| 11 | Bakery products | 0.75 (22) | 6.23 | 1.31 (7) | 3.59 | 0.94 (15) | 6.23 | 1.58 (5) | 3.73 |
| 12 | Sugar | 0.35 (33) | 4.55 | 0.80 (25) | 3.56 | 0.42 (28) | 4.55 | 1.15 (14) | 4.22 |
| 13 | Other food industries | 0.43 (28) | 5.80 | 1.00 (15) | 2.80 | 0.47 (25) | 5.80 | 1.24 (13) | 2.95 |
| 14 | Edible oils | 0.20 (37) | 4.93 | 0.73 (31) | 2.72 | 0.20 (34) | 4.93 | 0.79 (29) | 3.08 |
| 15 | Breweries and beverages | 0.11 (39) | 6.21 | 0.87 (22) | 1.97 | 0.13 (38) | 6.21 | 0.77 (30) | 1.64 |
| 16 | Ginning and textiles | 0.93 (13) | 4.19 | 1.04 (14) | 3.88 | 0.92 (16) | 4.19 | 1.11 (16) | 3.74 |
| 17 | Sawmills and wooden goods | 1.84 (5) | 4.42 | 1.67 (4) | 4.90 | 2.12 (5) | 4.42 | 1.79 (1) | 5.23 |
| 18 | Paper, printing, and publishing | 1.88 (4) | 4.23 | 1.76 (2) | 4.57 | 2.06 (6) | 4.23 | 1.77 (2) | 4.97 |
| 19 | Rubber and leather products | 1.22 (8) | 3.84 | 1.19 (11) | 3.90 | 1.37 (12) | 3.84 | 1.24 (12) | 4.16 |
| 20 | Basic chemicals, including fertilizers | 0.45 (27) | 2.47 | 0.41 (39) | 3.02 | 0.16 (36) | 2.47 | 0.20 (39) | 2.29 |
| 21 | Drugs and pharmaceuticals | 0.37 (32) | 5.49 | 1.00 (16) | 2.38 | 0.44 (27) | 5.49 | 1.00 (17) | 2.60 |
| 22 | Other chemicals | 0.39 (30) | 4.59 | 0.79 (20) | 2.42 | 0.45 (26) | 4.59 | 1.00 (18) | 2.70 |
| 23 | Glass and mineral products | 0.85 (17) | 4.48 | 0.99 (17) | 4.10 | 0.91 (17) | 4.48 | 0.87 (22) | 4.68 |
| 24 | Basic metal industries | 0.73 (23) | 1.86 | 0.62 (34) | 3.02 | 0.65 (20) | 1.86 | 0.48 (35) | 2.63 |
| 25 | Metal products | 1.05 (10) | 2.83 | 0.95 (18) | 3.53 | 1.24 (13) | 2.83 | 0.86 (23) | 4.09 |
| 26 | Machinery, except electrical | 0.37 (31) | 5.80 | 0.83 (23) | 3.15 | 0.34 (31) | 5.80 | 0.65 (32) | 3.21 |
| 27 | Electrical machinery | 0.21 (35) | 5.61 | 0.74 (30) | 2.67 | 0.22 (33) | 5.61 | 0.58 (33) | 2.42 |
| 28 | Railroad equipment | 0.87 (16) | 6.11 | 1.27 (9) | 4.24 | 0.51 (24) | 6.11 | 0.81 (26) | 3.88 |
| 29 | Motor vehicles, manufacture and repair | 0.83 (18) | 5.97 | 1.19 (10) | 4.22 | 0.91 (18) | 5.97 | 1.13 (15) | 4.77 |
| 30 | Bicycles and parts | 0.34 [illegible] | 6.07 | 0.88 (21) | 2.81 | 0.39 (30) | 6.07 | 0.79 (27) | 3.12 |
| 31 | Scientific and surgical instruments | 0.58 (25) | 5.78 | 1.05 (13) | 3.41 | 0.59 (22) | 5.78 | 0.90 (21) | 3.81 |
| 32 | Sports and athletic goods | 0.48 (26) | 6.24 | 1.27 (8) | 2.65 | 0.55 (23) | 6.24 | 1.27 (10) | 2.92 |
| 33 | Miscellaneous industries | 1.02 (12) | 5.83 | 1.12 (12) | 5.32 | 0.12 (39) | 5.83 | 0.30 (38) | 2.98 |
| 34 | Electricity, gas, and water supply | 1.05 (11) | 3.39 | 0.62 (35) | 5.89 | 0.63 (21) | 3.39 | 0.36 (37) | 5.93 |
| 35 | Construction | 0.80 (19) | 6.24 | 1.63 (5) | 3.60 | 0.19 (35) | 6.24 | 0.71 (31) | 2.55 |
| 36 | Trade, transport, and storage | 6.99 (1) | 1.32 | 1.72 (3) | 5.34 | 2.76 (2) | 1.32 | 0.79 (28) | 4.63 |
| 37 | Other services | 2.18 (3) | 4.43 | 2.02 (1) | 4.83 | 1.82 (7) | 4.43 | 1.64 (4) | 4.92 |
| 38 | Banking and insurance | 2.66 (2) | 3.48 | 1.61 (6) | 5.81 | 0.89 (19) | 3.48 | 0.57 (34) | 5.46 |
| 39 | Real estate and ownership of dwellings | 0.42 (29) | 6.24 | 0.43 (38) | 6.10 | 0.40 (29) | 6.24 | 0.41 (36) | 6.13 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Note: Figures in parentheses indicate rank.

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## Table 48—Linkage analysis of Punjab's economy, with import leakages, 1979/80

| Sector Number | Sector | R-Matrix | | | | Y′-Matrix | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $U_i$ | $V_i$ | $U_j$ | $V_j$ | $U_i$ | $V_i$ | $U_j$ | $V_j$ |
| 1 | Wheat | 1.72 (4) | 4.10 | 1.17 (13) | 5.38 | 2.15 (4) | 4.10 | 1.44 (10) | 5.46 |
| 2 | Rice | 1.06 (14) | 5.74 | 1.09 (16) | 5.59 | 1.63 (8) | 5.74 | 1.62 (5) | 5.77 |
| 3 | Cotton | 1.10 (12) | 5.13 | 1.00 (81) | 5.56 | 1.76 (7) | 5.13 | 1.56 (8) | 5.74 |
| 4 | Sugarcane | 1.16 (11) | 5.28 | 1.06 (17) | 5.70 | 2.08 (5) | 5.28 | 1.86 (3) | 5.85 |
| 5 | Gram and pulses | 0.56 (30) | 5.88 | 0.57 (33) | 5.76 | 0.96 (16) | 5.88 | 0.96 (23) | 5.84 |
| 6 | Oilseeds | 0.80 (25) | 4.83 | 0.66 (32) | 5.65 | 1.44 (12) | 4.83 | 1.16 (15) | 5.81 |
| 7 | Other agriculture and forestry | 0.98 (20) | 4.48 | 0.72 (31) | 6.08 | 1.83 (6) | 4.48 | 1.33 (12) | 6.13 |
| 8 | Animal husbandry | 1.64 (5) | 3.66 | 1.32 (10) | 4.59 | 2.58 (3) | 3.66 | 1.86 (2) | 5.08 |
| 9 | Dairy products and confectionery | 0.50 (33) | 5.37 | 0.76 (29) | 3.63 | 0.26 (29) | 5.37 | 0.60 (30) | 3.13 |
| 10 | Grain mill products | 0.91 (24) | 5.39 | 1.55 (6) | 3.76 | 0.17 (35) | 5.40 | 1.13 (17) | 3.76 |
| 11 | Bakery products | 0.50 (32) | 6.23 | 0.90 (25) | 3.55 | 0.38 (27) | 6.23 | 0.72 (26) | 3.36 |
| 12 | Sugar | 0.29 (35) | 5.40 | 0.44 (34) | 4.09 | 0.11 (37) | 5.40 | 0.42 (32) | 4.29 |
| 13 | Other food industries | 0.67 (27) | 5.99 | 1.06 (19) | 3.82 | 0.41 (26) | 5.99 | 0.98 (22) | 2.97 |
| 14 | Edible oils | 1.04 (17) | 5.54 | 1.31 (11) | 4.45 | 0.17 (34) | 5.54 | 0.70 (27) | 3.21 |
| 15 | Breweries and beverages | 0.61 (29) | 6.24 | 0.94 (23) | 4.01 | 0.23 (32) | 6.24 | 0.63 (29) | 2.65 |
| 16 | Ginning and textiles | 1.93 (3) | 4.74 | 1.79 (1) | 5.11 | 0.78 (18) | 4.74 | 1.07 (19) | 3.72 |
| 17 | Sawmills and wooden goods | 1.04 (15) | 5.19 | 1.06 (18) | 5.07 | 0.91 (17) | 5.19 | 0.96 (24) | 4.94 |
| 18 | Paper, printing, and publishing | 0.24 (37) | 5.05 | 0.26 (37) | 4.81 | 0.19 (33) | 5.05 | 0.21 (37) | 4.64 |
| 19 | Rubber and leather products | 1.04 (16) | 4.20 | 0.89 (26) | 4.78 | 0.61 (23) | 4.20 | 0.64 (28) | 4.00 |
| 20 | Basic chemicals, including fertilizers | 0.65 (28) | 3.46 | 0.42 (35) | 5.28 | 0.36 (28) | 3.46 | 0.29 (35) | 4.36 |
| 21 | Drugs and pharmaceuticals | 0.02 (39) | 5.55 | 0.03 (39) | 4.28 | 0.01 (39) | 5.55 | 0.02 (39) | 2.92 |
| 22 | Other chemicals | 0.05 (38) | 5.49 | 0.07 (38) | 4.14 | 0.02 (38) | 5.49 | 0.05 (38) | 2.66 |
| 23 | Glass and mineral products | 1.16 (10) | 5.10 | 1.12 (15) | 5.27 | 0.98 (15) | 5.10 | 0.99 (21) | 5.11 |
| 24 | Basic metal industries | 2.29 (2) | 2.38 | 1.02 (20) | 4.67 | 0.47 (25) | 2.38 | 0.40 (34) | 3.19 |
| 25 | Metal products | 1.64 (6) | 3.92 | 1.61 (4) | 4.17 | 0.75 (21) | 3.92 | 0.84 (25) | 3.79 |
| 26 | Machinery, except electrical | 0.49 (34) | 6.00 | 0.76 (30) | 4.04 | 0.24 (31) | 6.00 | 0.42 (33) | 3.70 |
| 27 | Electrical machinery | 0.51 (31) | 5.94 | 0.79 (28) | 3.99 | 0.24 (30) | 5.94 | 0.42 (31) | 3.62 |
| 28 | Railroad equipment | 1.07 (13) | 6.16 | 1.50 (7) | 4.41 | 1.04 (14) | 6.16 | 1.35 (11) | 4.74 |
| 29 | Motor vehicles, manufacture and repair | 0.93 (23) | 6.07 | 1.35 (8) | 4.30 | 0.78 (19) | 6.07 | 1.05 (20) | 4.55 |
| 30 | Bicycles and parts | 1.02 (18) | 6.13 | 1.65 (3) | 3.89 | 0.71 (22) | 6.13 | 1.14 (16) | 3.94 |
| 31 | Scientific and surgical instruments | 0.25 (36) | 5.83 | 0.35 (36) | 4.22 | 0.16 (36) | 5.83 | 0.24 (36) | 4.06 |
| 32 | Sports and athletic goods | 0.98 (22) | 6.24 | 1.60 (5) | 3.88 | 0.54 (24) | 6.24 | 1.08 (18) | 3.25 |
| 33 | Miscellaneous industries | 0.71 (26) | 5.97 | 0.79 (27) | 5.41 | 1.10 (13) | 5.97 | 1.20 (13) | 5.51 |
| 34 | Electricity, gas, and water supply | 1.25 (9) | 4.40 | 0.91 (24) | 6.11 | 1.60 (9) | 4.40 | 1.16 (14) | 6.09 |
| 35 | Construction | 0.98 (21) | 6.24 | 1.68 (2) | 3.85 | 0.77 (20) | 6.24 | 1.57 (7) | 3.63 |
| 36 | Trade, transport, and storage | 3.43 (1) | 2.06 | 1.31 (12) | 5.32 | 4.81 (1) | 2.06 | 1.78 (4) | 5.46 |
| 37 | Other services | 1.32 (8) | 4.94 | 1.34 (9) | 4.89 | 1.59 (10) | 4.94 | 1.62 (6) | 4.90 |
| 38 | Banking and insurance | 1.48 (7) | 4.48 | 1.15 (14) | 5.82 | 2.73 (2) | 4.48 | 2.07 (1) | 5.95 |
| 39 | Real estate and ownership of dwellings | 0.98 (19) | 6.24 | 0.99 (22) | 6.20 | 1.45 (11) | 6.24 | 1.45 (9) | 6.20 |

*(continued)*

## Table 48—Continued

| Sector Number | Sector | W′-Matrix $U_i$ | $V_i$ | $U_j$ | $V_j$ | N′-Matrix $U_i$ | $V_i$ | $U_j$ | $V_j$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Wheat | 1.24 (4) | 4.10 | 0.91 (19) | 5.04 | 2.10 (8) | 4.10 | 1.40 (10) | 5.62 |
| 2 | Rice | 1.20 (8) | 5.74 | 1.23 (10) | 5.62 | 2.48 (4) | 5.74 | 2.36 (3) | 6.02 |
| 3 | Cotton | 1.20 (7) | 5.13 | 1.09 (15) | 5.58 | 2.43 (5) | 5.13 | 2.10 (4) | 5.90 |
| 4 | Sugarcane | 1.10 (5) | 5.28 | 1.02 (16) | 5.65 | 2.16 (7) | 5.28 | 1.93 (5) | 5.86 |
| 5 | Gram and pulses | 0.60 (16) | 5.88 | 0.62 (26) | 5.71 | 1.26 (12) | 5.88 | 1.27 (12) | 5.87 |
| 6 | Oilseeds | 0.53 (12) | 4.83 | 0.47 (31) | 5.36 | 0.95 (16) | 4.83 | 0.80 (23) | 5.55 |
| 7 | Other agriculture and forestry | 1.09 (6) | 4.48 | 0.80 (24) | 6.08 | 2.22 (6) | 4.48 | 1.61 (6) | 6.15 |
| 8 | Animal husbandry | 1.82 (3) | 3.66 | 1.37 (9) | 4.89 | 3.70 (1) | 3.66 | 2.55 (1) | 5.30 |
| 9 | Dairy products and confectionery | 0.10 (29) | 5.37 | 0.44 (32) | 2.66 | 0.08 (36) | 5.37 | 0.54 (27) | 3.52 |
| 10 | Grain mill products | 0.21 (35) | 5.39 | 0.92 (17) | 3.04 | 0.25 (29) | 5.39 | 1.13 (14) | 3.75 |
| 11 | Bakery products | 0.61 (27) | 6.23 | 0.91 (18) | 4.17 | 0.79 (19) | 6.23 | 1.13 (15) | 4.36 |
| 12 | Sugar | 0.12 (37) | 5.40 | 0.46 (29) | 3.64 | 0.15 (33) | 5.40 | 0.46 (29) | 4.26 |
| 13 | Other food industries | 0.43 (26) | 5.99 | 0.89 (20) | 3.10 | 0.48 (24) | 5.99 | 1.10 (18) | 3.17 |
| 14 | Edible oils | 0.16 (34) | 5.54 | 0.55 (27) | 2.85 | 0.17 (31) | 5.54 | 0.57 (26) | 2.85 |
| 15 | Breweries and beverages | 0.10 (32) | 6.24 | 0.53 (28) | 2.49 | 0.12 (35) | 6.24 | 0.42 (30) | 2.08 |
| 16 | Ginning and textiles | 1.01 (18) | 4.74 | 1.21 (11) | 4.09 | 1.03 (14) | 4.74 | 1.32 (11) | 3.95 |
| 17 | Sawmills and wooden goods | 1.45 (17) | 5.19 | 1.45 (7) | 5.19 | 1.71 (9) | 5.19 | 1.60 (7) | 5.55 |
| 18 | Paper, printing, and publishing | 0.36 (33) | 5.05 | 0.37 (34) | 4.96 | 0.40 (26) | 5.05 | 0.38 (32) | 5.39 |
| 19 | Rubber and leather products | 0.84 (23) | 4.20 | 0.81 (22) | 4.32 | 0.97 (15) | 4.20 | 0.87 (22) | 4.58 |
| 20 | Basic chemicals, including fertilizers | 0.17 (28) | 3.46 | 0.20 (37) | 3.38 | 0.06 (37) | 3.46 | 0.09 (37) | 2.95 |
| 21 | Drugs and pharmaceuticals | 0.01 (39) | 5.55 | 0.02 (39) | 3.21 | 0.01 (39) | 5.55 | 0.02 (39) | 3.64 |
| 22 | Other chemicals | 0.02 (38) | 5.49 | 0.04 (38) | 2.86 | 0.02 (38) | 5.49 | 0.05 (38) | 3.11 |
| 23 | Glass and mineral products | 0.66 (15) | 5.10 | 0.80 (23) | 4.42 | 0.73 (20) | 5.10 | 0.72 (24) | 5.14 |
| 24 | Basic metal industries | 0.47 (25) | 2.38 | 0.48 (30) | 3.31 | 0.43 (25) | 2.38 | 0.36 (33) | 3.05 |
| 25 | Metal products | 1.12 (21) | 3.92 | 1.19 (12) | 3.98 | 1.35 (10) | 3.92 | 1.12 (16) | 4.72 |
| 26 | Machinery, except electrical | 0.27 (31) | 6.00 | 0.52 (29) | 3.61 | 0.26 (28) | 6.00 | 0.41 (31) | 3.90 |
| 27 | Electrical machinery | 0.16 (30) | 5.94 | 0.41 (33) | 3.23 | 0.17 (32) | 5.94 | 0.32 (34) | 3.29 |
| 28 | Railroad equipment | 1.39 (14) | 6.15 | 1.80 (5) | 4.77 | 0.84 (18) | 6.16 | 1.12 (17) | 4.63 |
| 29 | Motor vehicles, manufacture and repair | 1.17 (19) | 6.07 | 1.52 (6) | 4.73 | 1.33 (11) | 6.07 | 1.52 (8) | 5.30 |
| 30 | Bicycles and parts | 0.52 (22) | 6.13 | 1.11 (14) | 3.28 | 0.62 (23) | 6.13 | 1.03 (19) | 3.81 |
| 31 | Scientific and surgical instruments | 0.20 (36) | 5.83 | 0.30 (36) | 4.03 | 0.21 (30) | 5.83 | 0.27 (36) | 4.63 |
| 32 | Sports and athletic goods | 0.76 (24) | 6.24 | 1.45 (8) | 3.42 | 0.90 (17) | 6.24 | 1.49 (9) | 3.84 |
| 33 | Miscellaneous industries | 1.10 (13) | 5.97 | 1.19 (13) | 5.56 | 0.13 (34) | 5.97 | 0.28 (35) | 3.48 |
| 34 | Electricity, gas, and water supply | 1.14 (9) | 4.40 | 0.85 (21) | 5.94 | 0.70 (21) | 4.40 | 0.51 (28) | 6.02 |
| 35 | Construction | 1.27 (20) | 6.24 | 2.36 (4) | 3.90 | 0.31 (37) | 6.24 | 0.93 (20) | 2.99 |
| 36 | Trade, transport, and storage | 7.24 (1) | 2.06 | 2.68 (2) | 5.47 | 2.94 (2) | 2.06 | 1.22 (13) | 4.92 |
| 37 | Other services | 3.15 (10) | 4.94 | 2.95 (1) | 5.31 | 2.70 (3) | 4.94 | 2.42 (2) | 5.52 |
| 38 | Banking and insurance | 3.32 (2) | 4.48 | 2.55 (3) | 5.87 | 1.14 (13) | 4.48 | 0.92 (21) | 5.61 |
| 39 | Real estate and ownership of dwellings | 0.67 (11) | 6.24 | 0.69 (25) | 6.10 | 0.67 (22) | 6.24 | 0.68 (25) | 6.14 |

Source: Based on author's calculations from Punjab input-output table for 1979/80 (Table 44, Appendix 1).
Note: Figures in parentheses indicate ranks.

# APPENDIX 2: DESCRIPTION OF SECTORS IN THE PUNJAB ECONOMY, 1979/80

| Sector Number | Description[13] |
|---|---|
| 1 | Wheat |
| 2 | Rice |
| 3 | Cotton |
| 4 | Sugarcane |
| 5 | Gram and pulses |
| 6 | Oilseeds |
| 7 | Other agriculture and forestry—*Jowar,* maize, *bajra,* barley, potatoes, chilies, green fodder, jute, vegetables, fruits. Planting, replanting, and conservation of forests; gathering of uncultivated materials; charcoal-burning carried out in the forests; felling and rough cutting of trees; hewing or rough shaping of poles, blocks, and so forth; transportation of logs to the permanent lines of transport. |
| 8 | Animal husbandry—Breeding and rearing of animals and poultry, including veterinary services; production of milk and milk products; slaughtering, preparing, and dressing of meat; production of raw hides and skins, eggs, and raw wool; hunting and trapping. |
| 9 | Dairy products and confectionery—Manufacture of dairy products (201), sugar confectionery, cocoa and chocolates (including sweetmeats). |
| 10 | Grain mill products—Manufacture of grain mill products (204). |
| 11 | Bakery products—Manufacture of bakery products (205). |
| 12 | Sugar—Manufacture and refining of sugar (206); production of indigenous sugar, *gur, khandsari,* and so forth (207). |
| 13 | Other food industries (see edible oils)—Manufacture of other food products, for example, slaughtering, preparing, and preserving of meat (200); canning and preserving of fruits and vegetables (202); production of common salt (208); manufacture of ice (215); manufacture of starch (217); manufacture of prepared animal feeds (218); manufacture of food products not elsewhere classified (219); manufacture of chewing tobacco, *zarda,* and snuff (228). |
| 14 | Edible oils (14 contains other foods and edible oils)—Manufacture of hydrogenated oils, *vanaspati ghee,* and so forth (210); manufacture of other edible oils and fats (211). |

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[13] Figures within parentheses indicate industry codes according to the National Industrial Classification, 1970.

| Sector Number | Description |
|---|---|
| 15 | Breweries and beverages—Distilling, rectifying, and blending of spirits (220); wine industries (221); malt liquors and malt (222); production of country liquor and toddy (223); soft drinks and carbonated water (224). |
| 16 | Ginning and textiles—Manufacture of cotton textiles (230-239); manufacture of wool, silk, and synthetic fiber textiles (240-249); manufacture of textile products (including wearing apparel other than footwear) (260-269). |
| 17 | Sawmills and wooden goods—Manufacture of wood products, furniture, and fixtures (270-279). |
| 18 | Paper, printing, and publishing—Manufacture of paper and paper products, and printing, publishing, and allied industries (280-289); manufacture of stationery articles (387). |
| 19 | Rubber and leather products—Manufacture of leather and fur products, except repair (290-299); manufacture of rubber, plastic, petroleum, and coal products (300-307). |
| 20 | Basic chemicals, including fertilizers—Manufacture of basic industrial organic and inorganic chemicals (310); manufacture of fertilizers and pesticides (311). |
| 21 | Drugs and pharmaceuticals—Manufacture of drugs and medicines (313). |
| 22 | Other chemicals—Manufacture of paints and varnishes (312); manufacture of perfumes (314); manufacture of inedible oils (315); manufacture of turpentine, synthetic resins, plastic materials, and synthetic fibers such as nylon and terylene, except glass (316); manufacture of matches (317); manufacture of chemical products not elsewhere classified (319). |
| 23 | Glass and mineral products—Manufacture of nonmetallic mineral products (320-329); mining. |
| 24 | Basic metal industries—Basic metal and alloy industries (330-339). |
| 25 | Metal products—Manufacture of metal products and parts, except machinery and transport equipment (340-349). |
| 26 | Machinery, except electrical—Manufacture of machine tools and parts, except electrical machinery (350-359). |
| 27 | Electrical machinery—Manufacture of electrical machinery, apparatus, appliances, and supplies and parts (360-369). |
| 28 | Railroad equipment—Manufacture of locomotive parts (371); manufacture of railway wagons and coaches and parts (372). |
| 29 | Motor vehicles, manufacture and repair—Manufacture of motor vehicles and parts (374); manufacture of motorcycles, scooters, and parts (375); manufacture of transport equipment not elsewhere classified (379); repair of motor vehicles (373). |

| Sector Number | Description |
|---|---|
| 30 | Bicycles and parts—Manufacture of bicycles, cycle-rickshaws, and parts (376). |
| 31 | Scientific and surgical instruments—Manufacture of medical, surgical, and scientific equipment (380); manufacture of photographic and optical goods (381). |
| 32 | Sports and athletic goods—Manufacture of sports and athletic goods (385). |
| 33 | Miscellaneous industries—Other manufacturing industries, watches and clocks (382); manufacture of jewelry and related articles (383); manufacture of musical instruments (386); manufacture of miscellaneous products not elsewhere classified, such as costume jewelry, costume novelties, feather plumes, artificial flowers, brooms, brushes, lampshades, tobacco pipes, cigarette holders, ivory goods, badges, wigs, and similar articles (389). |
| 34 | Electricity, gas, and water supply—Generation and transmission of electric energy (400); distribution of electric energy to household, industrial, commercial, and other users (401); distribution of gas (410); water supply collection and purification, and distribution of water (420). |
| 35 | Construction—Construction, repair, and demolition of buildings, highways, streets and culverts, sewers and water mains, railway roadbeds, railroad subways, elevated highways, bridges, viaducts, drainage projects, and all other types of heavy construction; land draining and reclamation; waterways, water wells, airports and air strips, athletic fields, tennis courts, parking areas, communication systems such as telegraph and telephone lines, and all other construction. Also includes construction, repair, and demolition work undertaken as an ancillary activity by the state and for the use of an enterprise classified as any other industry. Thus the scope of this industry covers all own-account construction activities in addition to construction activities carried out by special trade contractors such as carpenters, plumbers, plasterers, and electricians (50-51). |
| 36 | Trade, transport, and storage—The activities considered in this sector are wholesale and retail trading (60, 61, 62, 63, 64, 65, 66, 67, 68), auctioneering, hiring out of durable goods and other allied activities: transport by railways; communication services rendered by the post and telegraph department; transport by other means, namely, mechanized and non-mechanized road transport, unorganized water transport, air transport, and services incidental to transport such as packing, carting, and travel agencies (70); operation of storage facilities (74). |
| 37 | Other services—Service sector includes education, research services, and libraries; medical and other health services; religious and other community services; legal services; business services; recreation and entertainment services; laundry, cleaning and dyeing, barbers and beauty shops, and other personal services; and services/activities not elsewhere classified, such as hotels, boarding houses, eating houses, cafes, and restaurants. |

| Sector Number | Description |
|---|---|
| 38 | Banking and insurance—Banking and insurance including commercial banks (scheduled and nonscheduled banks); banking department of Reserve Bank of India; post office savings bank accounts, cumulative time-deposit accounts, and national savings certificates; nonbanking financial services (except insurance and credit societies) that include the activities of stock exchanges, loan, investment, hire purchase and chit fund companies, and other nonbanking financial institutions, cooperative credit societies, life insurance (other than postal life insurance), postal life insurance, nonlife insurance such as fire insurance, and so forth. |
| 39 | Real estate and ownership of dwellings—Real estate and ownership of dwellings covers the activities of the persons engaged in the real estate sector and rental income originating from the residential dwellings. |

# APPENDIX 3: METHODOLOGY FOR CALCULATING MULTIPLIERS

## Methodology

The basic equational system used in this model is the following:

Let there be n sectors, each producing a domestic output X.

The ith sector disposes of its output and imports to various sectors and to final demand, then

$$X_{i1} + X_{i2} + X_{i3} \ldots\ldots\ldots\ldots + X_{in} + f_i = X_i + M_i,$$

where $f_i$ is the domestic final demand (that is, consumption, capital formation, government expenditures, and exports) and $M_i$ is the imports of commodity i.

That is,

$$X_{i1} + X_{i2} + X_{i3} + \ldots\ldots + X_{in} + f_i - M_i = X_i,$$

or

$$\sum_{j=1}^{n} X_{ij} + f_i - M_i = X_i,$$

where $X_{ij}$ is that part of output of sector i that goes as input into sector j.

Define

$$a_{ij} = \frac{X_{ij}}{X_j} \text{ and } b_i \frac{M_i}{X_i}.$$

The equation system

$$\begin{array}{lcr}
X_{11} + X_{12} + \ldots\ldots\ldots X_{1n} + f_1 - M_1 & = & X_1 \\
\vdots & & \vdots \\
X_{i1} + X_{i2} + \ldots\ldots\ldots X_{in} + f_i - M_i & = & X_i \\
\vdots & & \vdots \\
X_{n1} + X_{n2} + \ldots\ldots\ldots X_{nn} + f_n - M_n & = & X_n
\end{array}$$

now becomes

$$\begin{array}{lcr}
a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots a_{1n}X_n + f_1 - b_1X_1 & = & X_1 \\
\vdots & & \vdots \\
a_{i1}X_1 + a_{i2}X_2 + \ldots\ldots\ldots a_{in}X_n + f_i - b_iX_i & = & X_i \\
\vdots & & \vdots \\
a_{n1}X_1 + a_{n2}X_2 + \ldots\ldots\ldots a_{nn}X_2 + f_n - b_nX_n & = & X_n.
\end{array}$$

Transporting and collecting terms:

$$\begin{array}{l}
(1 + b_1 - a_{11})X_1 - a_{12}X_2 \ldots\ldots\ldots\ldots - a_{1i}X_i \ldots\ldots - a_{1n} X_n = f_1 \\
\vdots \\
- a_{21} X_1 + (1 + b_2 - a_{22}) X_2 \ldots - a_{2i}X_i \ldots\ldots - a_{2n} X_n = f_2 \\
\vdots \\
- a_{i1} X_i - a_{i2} X_2 \ldots\ldots + (1 + b_i a_{ii})X_i \ldots\ldots - a_{in} X_n = f_i \\
\vdots \\
- a_{n1} X_1 - a_{n2}X_2 \ldots\ldots - a_{ni}X_i \ldots + (1 + b_n - a_{nn})X_n = f_n ,
\end{array}$$

or, using matrix notation,

$$(I + \hat{b} - A) X = F, \quad \text{or}$$

$$(I + \hat{b} - A)^{-1} F = X,$$

where I is the unit matrix of dimension n, $\hat{b}$ is the diagonal matrix with elements $b_i$, A is the coefficient matrix,

$$A = \left| \begin{matrix}
a_{11} a_{12} \ldots a_{1i} \ldots a_{1n} \\
a_{21} a_{22} \ldots a_{2i} \ldots a_{2n} \\
\vdots \\
a_{i1} a_{i2} \ldots a_{ii} \ldots a_{in} \\
\vdots \\
a_{n1} a_{n2} \ldots a_{ni} \ldots a_{nn}
\end{matrix} \right| ,$$

and F is a column vector of final demands, so that

$$F = \left| \begin{matrix} f_1 \\ f_2 \\ \vdots \\ f_n \end{matrix} \right| .$$

Let

$$(1 + \hat{b} - A)^{-1} = \left| \begin{matrix}
A_{11} A_{12} \ldots\ldots\ldots A_{1n} \\
A_{21} A_{22} \ldots\ldots\ldots A_{2n} \\
\vdots \\
A_{n1} A_{n2} \ldots\ldots\ldots A_{nn}
\end{matrix} \right| .$$

The levels of direct and indirect output in the various sectors associated with a unit of final demand in any sector are represented by the relevant vector. Thus, one unit of final demand from sector 1 will lead to the following production levels:

$$\begin{vmatrix} A_{11}A_{12}\ldots\ldots\ldots\ldots A_{1n} \\ A_{21}A_{22}\ldots\ldots\ldots\ldots A_{2n} \\ \cdot \\ \cdot \\ \cdot \\ A_{n1}A_{n2}\ldots\ldots\ldots\ldots A_{nn} \end{vmatrix} \quad \begin{vmatrix} 1 \\ 0 \\ \\ \\ \\ 0 \end{vmatrix} = \begin{vmatrix} A_{11} \\ A_{21} \\ \cdot \\ \cdot \\ \cdot \\ A_{n1} \end{vmatrix}.$$

Let

$$V = (v_1\, v_2 \ldots . v_i \ldots . v_n), \tag{1a}$$

where $v_1, v_2 \ldots . v_n$ represent value added per unit of output in the respective sectors.

Therefore, the direct and indirect income generated by one unit of final demand in sector 1 will be

$$\begin{vmatrix} V_1 V_2 \ldots . V_i \ldots . V_n \end{vmatrix} \quad \begin{vmatrix} A_{11} \\ A_{21} \\ \cdot \\ \cdot \\ \cdot \\ A_{n1} \end{vmatrix} = \begin{vmatrix} V_1A_{11} + \ldots + V_nA_{n1} \end{vmatrix}.$$

Similarly, the direct and indirect income generated by one unit of final demand in sector i will be

$$V_1 A_{1i} + V_2 A_{2i} \ldots\ldots\ldots V_n A_{ni}. \tag{2a}$$

Direct and indirect sectoral income multipliers per unit of final demand are given by dividing (2a) by the respective element in (1a).

Since one unit of final demand in sector i gives $A_{ii}$ units of output in that sector, $1/A_{ii}$ units of final demand would yield one unit of output in sector i. Hence, direct and indirect income generated per unit of output in sector i would be given by

$$\frac{1}{A_{ii}} \begin{vmatrix} V_1 A_{1i} + V_2 A_{2i} \ldots\ldots\ldots + V_n A_{ni} \end{vmatrix}. \tag{3a}$$

The direct and indirect sectoral income multipliers per unit of output are given by dividing each element of (3a) by the corresponding element in (1a). Direct and indirect sectoral wage income and employment multipliers are obtained similarly.

## Direct and Indirect Consumption Multipliers and Induced Incomes

To derive consumption multipliers, the Punjab table was closed with respect to consumption and wage and nonwage income. The closing of the model was done on the assumption that a certain proportion of net value added in each sector is devoted to consumption. This proportion is derived from the average propensity to consume, which worked out at 0.7171 in 1969/70 and 0.6894 in 1979/80. The augmented column was the coefficient vector for total consumption and the augmented row was obtained by multiplying the net value added by the average propensity to consume.

The $(n + 1, n + 1)$ term of the inverted $(I + \hat{b} - A)$ matrix gives the consumption multiplier.

The respective elements in the last row in the inverted matrix give direct, indirect, and induced income generated per unit of final demand in that sector. Let these be denoted by

$$V'_1 V'_2 \dots\dots\dots V'_n. \qquad (4a)$$

The direct, indirect, and induced sectoral income multipliers per unit of final demand are obtained by dividing the elements of (4a) by their respective direct income given in (1a). Further dividing these elements by the diagonal output levels yields direct, indirect, and induced sectoral incomes per unit of output. These are

$$\frac{V'_1}{A'_{11}} \; \frac{V'_2}{A'_{22}} \; \dots\dots\dots \; \frac{V'_n}{A'_{nn}}, \qquad (5a)$$

where $A'_{11}, A'_{22} \dots . A'_{ii} \dots . A'_{nn}$ are diagonal elements in the inverted augmented matrix. Direct, indirect, and induced sectoral income multipliers per unit of output are obtained by dividing each element of (5a) by the direct sectoral income given in the corresponding element in (1a).

The direct, indirect, and induced sectoral wage income and employment multipliers are obtained similarly.

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83

# DEVELOPMENTAL IMPACT OF RURAL INFRASTRUCTURE IN BANGLADESH

**Raisuddin Ahmed**
**Mahabub Hossain**

October 1990

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**Raisuddin Ahmed**
**Mahabub Hossain**

**Research Report 83**
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# FOREWORD

The appropriate role for infrastructure, particularly rural infrastructure, in the economic development of developing countries has remained a largely unexplored and underrated issue. A dearth of case studies focusing on the nature and magnitude of the effects of infrastructure is partly responsible for this state of affairs. Realizing the potential role of infrastructure in a strategy of growth based on farm and nonfarm rural sectors, IFPRI launched a program of studies on rural infrastructure in selected countries of Asia and Africa. A series of papers prepared for a seminar on Infrastructure and Agricultural Development held in Mexico City in January 1988 have been published as IFPRI Policy Briefs 3. This case study on Bangladesh, conducted in collaboration with the Bangladesh Institute of Development Studies, is the first major project completed under the program. We believe that it will clear up many of the misconceptions that shroud the decisionmaking process in allocation of public resources.

it is true, however, that there is a need to go beyond this impact study to examine the aggregate dimensions of public expenditure and to build political institutions for the development of infrastructure. Thus the supply-side of infrastructural development is also an important part of the process—a part that this study does not address. It is hoped that these supply-side issues wil be considered in future IFPRI research.

A final word on the limitations inherent in extrapolating the findings of this study to other developing countries. Although many generalizations are expected to be valid in the context of other Asian and African countries, it must be recognized that a positive impact of infrastructure also depends on the overall policy environment of a country. Infrastructural development is not a substitute for effective policies: instead it provides a congenial environment for public policies and private investment to perform and prosper.

Finally, based on the evidence in this report, the importance of infrastructure in rural development in Bangladesh cannot be overstated. We at IFPRI hope that Ahmed and Hossain's seminal work will stimulate a number of additional analyses in this neglected area of research.

Just Faaland

Washington, D.C.
October 1990

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Collaboration with the Bangladesh Institute of Development Studies enriched the quality of the study with hard facts on national, regional, and household-level attributes and activities. Our deepest gratitude goes to Rehman Sobhan, the then director-general of BIDS, for his help in setting up the field surveys and for making the collaboration between the two institutes a productive one in all respects.

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Raisuddin Ahmed
Mahabub Hossain

# 1

# SUMMARY

This study empirically addresses issues in the neglected area of research on how infrastructure affects growth of income and alleviation of poverty in a developing economy. Contrary to the conventional view that development of rural infrastructure is likely to aggravate poverty, it finds that the development of rural infrastructure has far-reaching implications for the alleviation of poverty by indirectly generating income.

The study focuses on household economies in Bangladesh and concentrates on the benefits of infrastructure, particularly for the poorest segments of the population. It identifies, describes, and measures the effects of development of rural infrastructure on agricultural production, employment, income, consumption, savings and investment, and market and social development. Because transport and roads are the key contributors to development in rural areas, they are the primary form of infrastructure considered here.

Estimates of user-cost savings typically used to measure the effects of new roads in developed countries are not adequate for measuring the profound structural changes brought about by the construction of infrastructure in developing countries. Studies to measure the effects of road development, electrification, and institutional development have primarily focused on agricultural production and emphasized the contribution of individual factors when these factors are highly correlated. This study attempts to balance descriptive material with statistical analysis, using two methods to separate the pure effects of infrastructure from other factors. First, 16 villages were carefully selected from a larger sample of 129 so that natural endowments such as soil, topography, and water are evenly distributed. Target variables—income, for example—are compared among villages grouped according to their degree of infrastructure development. Second, econometric techniques are applied to provide a more complex measurement.

Field data were collected from about 640 households through five questionnaires administered during the calendar year 1982. Based on the data from this survey, a common index was constructed for all elements, which was used to rank villages according to their degree of infrastructure development. Villages, evaluated by their access to transport, markets, modern inputs, electricity, and social services, are divided into two groups—developed and underdeveloped.

Infrastructure affects agricultural production indirectly through prices, diffusion of technology, and the use of inputs. In estimating the extent of these effects, comparing data for the three most developed villages and the three least developed, the study finds that the price paid to farmers for paddy is about the same in all of the villages, but fertilizer prices are 14 percent lower and labor costs 12 percent higher in the developed villages than in the underdeveloped. Moreover, 105 percent more farmland is irrigated, 71 percent more is sown with high-yielding varieties (HYVs), and use of fertilizer is 92 percent higher in developed villages.

These differences in adoption of new technology and prices had only a small effect on the total use of labor, but they had a substantial effect on the composition of that total use. The combined effects of wider and more efficient use of new technology as a result of infrastructure development is estimated to have increased agricultural production in developed areas as much as 32 percent.

Infrastructure development indirectly affects the composition of employment by making nonagricultural jobs more accessible to those with better skills and some assets. This leads to a reduction in the use of family labor and an increase in the use of wage labor in agriculture, providing employment for those with marginal or no land.

The most important finding of the study is the profound effect that infrastructure has on incomes of the poor. Overall, estimations based on the most and least developed villages indicate that infrastructural endowment causes household income to rise by 33 percent: income from agriculture increases about 24 percent, that from livestock and fisheries about 78 percent, that from wages almost doubles, but income from business and industries only rises by 17 percent. Most striking, however, is the distribution of these increases: the functionally landless and small farmers garner a larger share of the increases from crops, wages, and livestock and fisheries, while the large landowners capture most of the smaller increase in business and industries.

Households in developed areas spend a larger share of this incremental income on noncereal foods, nonfoods, and services, which generates additional rounds of economic growth. The diminishing propensity to consume cereals (48 percent in developed villages as opposed to 60 percent in underdeveloped) reflects changing taste patterns and a wider range of choices. The question is whether the increasing demand engendered by rising incomes can be met by increasing supply. According to this study, infrastructure development increases the speed of diffusion of agricultural technology, reduces the cost of marketing, and improves the operation of both input and product markets, through improved linkages with other sectors.

A comprehensive framework is used to measure the influences of infrastructure on household savings and investment, a key factor in sustaining economic growth. The savings rate, which averages about 14 percent, is slightly higher in developed villages. However, about 36 percent of the households in all income groups have no savings at all, while 75 percent of savings are generated by households in the top two income deciles.

About 78 percent of savings can be attributed to capital formation and 22 percent to transfer-type transactions such as lending through mortgages, land purchases, and money lending. Nonmonetized investment is 62 percent higher in underdeveloped villages than in developed. But gross investment per household is about 14 percent higher in developed villages, even though investment in irrigation, drainage, and agricultural equipment is 27 percent smaller in developed villages. Because households in underdeveloped areas hold 34 percent more land, this difference disappears when investments are calculated on the basis of per unit of land owned rather than by household.

Infrastructure development encourages savings and investment indirectly through its positive effect on income. Current income is shown to be the dominant factor in determining how much a household saves. Estimates of the marginal propensity to save vary from 34 to 40 percent. To increase opportunities for productive investment in Bangladesh, infrastructure development must go hand in hand with other incentive policies—institutional credit for the poor, for example. Friends, relatives, and moneylenders are still the major sources of credit in rural areas, especially for the landless and small landowners; what institutional credit is available mostly goes to large landowners. Infrastructure development is found to improve access to institutional credit almost sevenfold.

Illiteracy is widespread in Bangladesh, where 60 percent of the population above age five has never attended school. In examining the effects of infrastructure on social development, such as education and health conditions in rural areas, development of infrastructure did not have a significant direct effect on literacy, which appears to be closely related to the size of a household's landholding and a person's sex. The study does show, however, that infrastructure development has a positive effect on health.

Because the effects of infrastructure on rural development are so definitive in agriculture-based, low-income developing countries, a fresh look at policies to encourage rural infrastructure development is called for. All potential infrastructure projects should be identified, ranked according to their benefit-cost ratios, and funded accordingly. But determining benefits is a challenging task, and good judgment will always be required. In addition, strong local government institutions should be built up, the flow of government funds should be linked to local initiatives, and revenue sharing between local and central governments should be arranged.

In recent years, structural adjustment policies that discourage public expenditure have taken precedence over development of infrastructure. In light of the positive effects of rural infrastructure found in this study, the donor community should restore infrastructure development to high priority.

# 2

# INTRODUCTION

"Infrastructure" is a frequently used word, but there is no consensus in economic literature on its precise meaning. The terms "infrastructure" and "social overhead capital" are often used interchangeably. Lewis (1955) prefers to include public utilities, ports, water supplies, and electricity in the definition of infrastructure. Higgins (1959) includes transport, public utilities, schools, and hospitals. Hirschman (1959) lists facilities for law and order, education, public health, transportation, communications, power, water supply, irrigation, and drainage. He makes a distinction between a wider concept of social overhead capital, as listed above, and a "hard core" limited to transportation and power. He sets out four conditions for distinguishing social overhead capital from directly productive activities: (1) the services provided by the activity are to facilitate, or in some sense are basic to, the carrying out of a wide variety of economic activities; (2) the services are provided in practically all countries by public agencies or by private agencies subject to public control and are provided free of charge or at rates publicly regulated; (3) the services cannot be imported; and (4) the investment needed to provide the services is characterized by "lumpiness." In the 1960s, the importance of agriculture in economic development was increasingly recognized, and the literature of that period reflects this added emphasis on agricultural research and extension, rural financial institutions, and irrigation and drainage (Nicholls 1963, De Vries 1960, Ishikawa 1967).

The focus of this study is rural infrastructure. Therefore, some elements mentioned above—port facilities, for example—are not directly relevant. The elements of rural infrastructure included in this study are specified in a later section, where an objective measure of rural infrastructure is presented in the form of infrastructure indices. The exclusion of urban and first-order infrastructures, such as national highways, railways, and ports, does not imply a downgrading of their importance. Rural infrastructures are like the secondary and tertiary arteries of the body, as critical as the main arteries for blood circulation.

## Role of Infrastructure in Development

The role of infrastructure is complex and its effects are indirect. Consequently, development economists have not focused on infrastructure as much as they have on directly productive activities such as agriculture and industry. However, numerous models of development and discrete studies of growth have generated explanations of growth and development that imply a strategic but often hidden role for infrastructure. This is particularly true of models that assign a special role to agriculture. For example, von Thunen's (1842) attempt to explain geographic variations in the intensity of farming systems and productivity of labor in an industrial country is focused on urban-industrial pull and the implied critical roles of transport and communication systems in the strength of that pull. The pull effect of urban and rural growth centers—the foci of development—on the rest of the economy is similarly dependent on the physical transport and communication linkages. Ruttan's (1984) "frontier model," which contends that rapid agricultural growth in North and South America and Australia is explained by the opening up of new land, has the transportation and communication infrastructure as its central foundation. Similarly, his "diffusion model," which formulates the process of technological spread in agriculture as a source of dramatic growth in agricultural production, is critically dependent on physical and institutional infrastructure (Ruttan 1984). Mellor's (1976) outline for the future economic development of India places infrastructure development near the top of his list of priorities. He makes a particular effort to establish the strategic role of infrastructure in producing a large multiplier effect in the economy, arising from agricultural growth and the expenditure of the resulting agricultural income on consumption.

In addition to these broad generalizations, there are numerous studies with narrow foci that began as searches for knowledge on a certain subject, with only incidental interest in infrastructure, but found profound effects of infrastructure. Results from some of these cases will be cited in the course of discussion of the impact of infrastructure development.

Infrastructure's ability to reduce the cost of marketing agricultural products is obvious and well known. Perhaps this effect of infrastructure is more important in Africa than anywhere else. An IFPRI study shows that African farmers receive only 30-50 percent of the final prices paid by consumers, compared with 70-85 percent of prices received by farmers in Asia (Ahmed and Rustagi 1987). About two-thirds of this difference is attributable to the substantial difference in transportation costs between countries in the two continents—a factor directly related to transport infrastructure. However, thinness of volume of production and marketable surplus (which can be measured as volume per square mile of area) is also a significant reason for higher transportation costs in Africa than in Asia. Infrastructural development indirectly affects thinness by influencing the productivity of land and the marketing rate of a given product, thereby increasing the volume of trade and reducing the transportation cost per unit of traded volume.

Marketing margins have far-reaching consequences for the comparative advantage of products of a country and its competitive strength in the world market. Very high marketing margins in agricultural products, when added to production costs, often make the f.o.b. price larger than that in competing countries. Similarly, internal transport costs, when added to the c.i.f. price, make the domestic price of imported products quite high, reducing the scope of trade. High marketing margins therefore tend to reduce the scope of international trade between developing and developed countries.

The effect of underdeveloped infrastructure on transmission of price is by no means inconsequential. Lack of infrastructural facilities is the principal source of market fragmentation and blurring of the transmittal of price signals. One study shows that the short-run effect of devaluation of the exchange rate is reflected in prices at the farm level to the extent of about 50 percent in the Asian context but without any systematic effect in African countries (Scandizzo 1984).

Labor is the most important factor in the production of agricultural goods and in the income of rural households in developing countries. Imperfections in rural labor markets, particularly interlocking of labor markets with land, credit, and product markets, has traditionally been viewed as a crucial constraint on income and employment of rural labor households (Bardhan 1979; Bardhan and Rudra 1978). Most of these imperfections in the labor market may be traced directly and indirectly to infrastructure underdevelopment.

The interlocking of labor markets with land and credit markets arises from the lack of opportunity for alternative jobs in the rural market. Labor households would not have to be bonded to large farmers through sharecropping if they had access to nonfarm work. Similarly, earning opportunities outside agriculture would help alleviate the cash constraints in labor households that drive them to moneylenders who charge high interest rates.

Under the structure of farm holdings in most countries of Asia, a large proportion of small farmers are also part-time wage laborers. Because their labor is demanded on farms during peak seasons, they cannot move far from the village in search of jobs or commit labor to outside activities on a sustained basis. The degree to which such farmers can participate in the out-of-the-village job market depends on how fast they receive information on outside jobs, the distance to such jobs, and the transport facilities between villages. This aspect of creating nonfarm jobs for farm households will become particularly critical for countries like Bangladesh, where, by the turn of the century, more than 80 percent of the farmers will hold less than 2.5 acres of land. Farmers need to remain on the farm and yet have access to nonfarm employment. This is unlikely without large-scale infrastructure development in rural areas (Ahmed 1987).

As the result of social custom and low wage income, earning income from labor in rural areas is often looked down upon as a low-caste activity (Thorner and Thorner 1962). This creates a tendency among self-employed small farmers who have only recently descended to this status to avoid the wage-labor market even if they have considerable surplus labor to offer. A dualism between family labor and wage labor markets thus develops. If such laborers could get jobs far from the village where they are not known personally, they would not hesitate to participate in the wage-labor market. This possibility, of course, depends at least partly on transportation. Social custom also restrains participation of women in the labor force. Certain nonfarm jobs that could be performed in the household, such as rice milling and processing, help to break down this social barrier, allowing women to enter the labor market.

A logical consequence of the expansion of product and factor markets as argued above is the concurrent development of specialization in production. Two types of specialization are important in rural areas: one involves specialization in certain agricultural products and the other involves specialization between agricultural and nonagricultural enterprises, including processing of agricultural products. Many of these products are perishable and must be brought to market daily for minimum loss. Moreover, farmers may also produce bulky crops such as sugarcane and cassava, which involve high transportation costs. Consequently, farmers in remote, isolated villages are likely to concentrate on agricultural products that are needed for home consumption, are less bulky, and are nonperishable. They may have to engage in subsistence production of low-profit perishable crops because these cannot be easily marketed. With specialization, the cash flows of farmers in infrastructurally developed areas are likely to be higher than those of farmers in underdeveloped areas. In turn, this cash flow relaxes credit constraints, making it possible to purchase modern inputs.

The second type of specialization diverts resources of large landowners to nonagricultural trade and processing activities. Instead of attempting to farm a large area with hired labor, which can often be managerially inefficient, large farmers have the option to expand into nonagricultural business, operating from the household, if infrastructure development provides easy access to markets. This may even reduce the concentration of landholding and inequality in the distribution of agricultural income.

Infrastructural facilities are considered essential for diffusion of technology in agriculture for a number of reasons. Extension workers travel frequently in areas where transport and communications function better. Demonstration plots by agricultural extension workers tend to be established in areas with better infrastructure. Supervision of extension work also is limited to developed areas. Under traditional farming, inputs are available in the village. Modern agricultural inputs, however, such as fertilizer, pesticides, and implements (tubewells, for example) are produced in urban areas. Infrastructural facilities are essential for distribution of these modern inputs from urban areas to farmers spread throughout the countryside. Transportation of equipment for drilling even small, shallow tubewells becomes problematic in the absence of good infrastructure. Concentration of tubewells in areas with well-developed infrastructure is a likely outcome. The distribution of fertilizer and high-yielding seed varieties (HYVs) is likely to be more extensive in infrastructurally developed than in underdeveloped areas for many reasons, including distribution cost. Similarly, access to institutional services such as health care, education, and credit is likely to be better in developed than in underdeveloped villages. Also, credit constraints are expected to be lower in areas with developed infrastructure because of a high degree of specialization and commercialization of production, including nonfarm sources of income.

The impact of infrastructure on the pattern of household consumption is likely to be substantial. It is realized through changes in prices and expansion of demand. The price effect is quite obvious and easily recognized, but the demand effect is not. Largely as the result of price differences between locally produced and imported goods, average and marginal propensities to consume locally produced goods tend to be higher than those of imported goods in infrastructurally underdeveloped villages. The expansionary demand effect can be explained by the concept of latent demand. Many products, particularly services, are not available at a reasonable cost in infrastructurally underdeveloped areas, so consumption of these products and services is thin in such areas. When no transport service is available, even a rich man must walk to a distant place. As soon as transport service is extended to the village, the latent demand for the service becomes effective demand. The linkage of household demand to the second or third rounds of economic activity is quite strong. This multiplier effect, in the context of a Malaysian rural area, was equivalent to 75 cents out of a dollar's worth of incremental income that was the indirect effect of an original investment in infrastructure (Bell, Hazell, and Slade 1982).

Policymakers often stress the need for increasing nonfarm employment, particularly in rural areas, but they often wonder how to do it effectively. Increased production in main sectors like agriculture and industry is, of course, a necessary condition, but more important is the strategy—the way in which the production increase is brought about. That infrastructure is a critical element in that strategy is demonstrated in an International Labour Organisation study that compares Taiwan, the Republic of Korea, Japan, and China (Saith 1986). This study finds that Korea and Taiwan share similar growth paths and historical backgrounds but achieve a quite different degree of success in rural nonfarm income and employment. In Taiwan, about 80 percent of rural income is received from nonfarm sources, compared with less than 48 percent in Korea. Seventy percent of farm households in Taiwan had access to electricity even in 1960, compared with only 13 percent in Korea. Density of paved roads in Taiwan was 76 kilometers per 1,000 square kilometers in 1962 and 215 kilometers in 1972, whereas in Korea less than 10 kilometers per 1,000 kilometers were paved in 1966 and less than 50 kilometers in 1975 (Saith 1986).

The foregoing discussion by no means covers all possible facets of infrastructure and its impact on the rural economy. The effects on household savings and investment behavior cannot be hypothesized on the basis of a priori logic. Empiricism is the only way. However, it is well-known in a number of countries that infrastructural backwardness is a basic cause of ineffective administration of various welfare measures and their distribution to the rural poor. As Malenbaum (1962) argues in the context of India, change in social attitude is one of the greatest challenges for economic development. For example, social taboos and religious orthodoxies are known to frustrate progress in the family planning programs of many developing countries. The process of attitudinal change in the rural population is hastened by the movement of people and ideas, which the development of rural infrastructure indirectly facilitates.

## Scope of the Study

The primary objectives of the study are to identify, describe, and measure the effects of rural infrastructure on agricultural production, employment, income, consumption, savings and investment, and market and social development. The focus is on household economies in rural areas. Although emphasizing the household level provides a picture of the effects of infrastructure development, it does not capture the effects of infrastructure on nonhousehold sectors such as corporate bodies. In this sense, the estimates of the contribution of infrastructure development are partial.

It is clear from the objectives that the emphasis of the study is on the benefits of infrastructure development, which is appropriate because it is the benefits of infrastructure that are imperfectly known and often a source of controversy in resource allocation. Analysis of issues relating to the supply side (including allocation of public resources, maintenance of infrastructure, and institutional development at local levels for construction, maintenance, and resource mobilization) is planned for a second study under consideration.

# 3

# RESEARCH METHODOLOGY AND DATA

A comprehensive review of the literature on infrastructure (Ahmed and Donovan 1989) demonstrates that there is a glaring gap in the methods for measuring effects of infrastructure. Most empirical studies are concerned with measurement of the impact of a discrete element rather than of a composite group consisting of a number of infrastructural elements. Studies on the effects of transport development are a classic example. Benefits of investment in transport development are measured by the "user cost savings" arising from the development. The approach to estimating user cost savings as a measure of benefits from a road project is shown in Figure 1. In the figure, DD is the demand curve for transport services, whereas the horizontal axis represents the volume of traffic and the vertical axis represents the unit cost of transportation. When walking and headloading were the means of transport (before the road project), the unit cost was $0C_1$ and the volume of traffic $0Q_1$. This cost was reduced to $0C_2$ when the road was developed. This reduction also induces additional traffic $(0Q_2 - 0Q_1)$, which is determined by the demand elasticity of DD. Note that this additional traffic is not considered to have arisen as the result of structural change brought about by the road project. The total benefit from development of the road is given by the area $AC_1C_2B$, which consists of two components:

Cost savings on existing traffic $= (0C_1 - 0C_2)0Q_1 = AC_1C_2E$, and

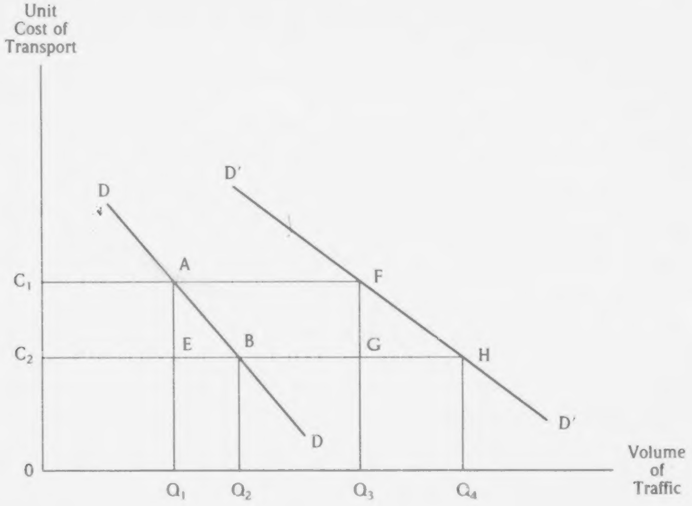
Cost savings on generated traffic $= \frac{1}{2}(0C_1 - 0C_2)\,(0Q_2 - 0Q_1) = AEB$.

This conventional approach (see van der Tak and de Weille 1969) is applicable in developed economies where resources are fully employed. In developing economies where resources are under- or unemployed, road development usually brings about substantial structural change. If this happens, the demand curve will shift to the right, D′D′. Under this new situation, the benefit from additional traffic generated will be ABHF, which is much larger than the benefit AEB from additional traffic under static demand conditions (DD). It would, however, be a serious underestimation of development economists to assume that they failed to see this simple logic and ignored the large benefit that arises from the shift of demand. The omission nevertheless occurs often as the result of the vacuum in factual information.

It is quite clear that the amount of structural change that can be brought about through infrastructure development is the fundamental issue. Even though most of the literature on the methodology of evaluating infrastructure is rich in advice on what prices should be used and what criteria should be adopted (for instance, on the internal rate of return versus the cost-benefit ratio), very few methodological innovations for measuring the extent of structural change can be learned from the literature. Moreover, the extent of structural change depends greatly on the interaction among various elements of infrastructure and technology. Unraveling the effects of these interactions is a challenging task.

In recent years, some researchers have used econometric techniques to measure the effects of road development, electrification, and institutional development (schools,

**Figure 1—Model for measuring the effects of transport development**



markets, and so forth) on agricultural production (Binswanger, Khandker, and Rosenzweig 1989, Antle 1983, Barnes and Binswanger 1986, and Beenhakker et al. 1987). Most of these empirical studies are based on intercountry or interdistrict cross-section, time-series analysis. For example, the study by Binswanger, Khandker, and Rosenzweig (1989) estimates the contribution of output prices, fertilizer prices, wage rates, irrigation, education, electricity, roads, markets, and environmental factors to the growth of agricultural output in India, using district-level measures of various variables. They found the contribution of the infrastructural variables very high; combined effects of these variables were almost 2.5 times greater than the contribution of irrigation. The problem with this type of analysis is the unreliability of estimates of the contribution of individual factors when these factors are highly correlated. Multicollinearity has never been satisfactorily solved, even though sophisticated statistical techniques are available to tackle the problem. Moreover, district data are always questionable for this type of analysis. Therefore, such results are hardly likely to convince policymakers.

## Methodological Approach and the Data

The basic method adopted for measuring the effect of infrastructure is comparison of relevant target variables (for example, income) among villages with various degrees of infrastructure development. The drawback to this approach is the probability of other factors contaminating the pure effect of infrastructure, which was minimized through two main procedures. First, the 16 villages that constitute the sample for this study of rural Bangladesh were selected from an initial survey of 129 villages, so that soil and agronomic factors, topography, and water regimes associated with the study villages were either uniform or evenly distributed across a wide spectrum of infrastructure endowment. The researchers from the Bangladesh Institute of Development Studies and the International Food Policy Research Institute, who were involved in the survey, spent a considerable amount of time selecting 16 villages from a population of 129. The villages identified as the most infrastructurally backward could not always be included in the sample of 16, mainly because of the problem of data collection. Transport to and lodging of interviewers in some villages were so difficult that those villages had to be excluded from the sample.

In distinguishing the effects of infrastructure from other sources of influence, the second procedure adopted is econometrical. The econometric techniques used for different purposes are explained in the relevant sections of this report. In order to provide a flavor of the underlying processes of change and the relationships that exist, descriptive material is balanced with results of statistical analysis, which are more complex.

Information collected through a 1982 survey of households in the 16 villages, located in various parts of Bangladesh, constitute the basic data used in the study. An average village contains about 160 households with a total population of about 950 people. A census was conducted in each of the villages to collect information on the landholdings and occupational structure of each household. The households were classified into eight groups based on the size of landholding (four groups) and the occupation of the head of the household (two groups). Then a proportionate random sample was drawn from each stratum so as to have 40 households from each village. A total of 640 households from the 16 villages was selected in this way. In the course of editing, however, a few households had to be excluded due to unreliable information. The final set of households used in the analysis was marginally smaller than 640.

Field data in the form of five sets of structured questionnaires were collected throughout the calendar year. Questionnaire 1 collected detailed statistics on household characteristics, assets, and liabilities. Questionnaire 2, on costs and returns in farm production activities, was administered three times during the year, after each crop season: aus, the summer season; aman, the autumn; and boro, the winter season. Questionnaire 3 was conducted eight times during the year to collect information on weekly expenditures on food and nonfood necessities, nonfarm income and employment of family workers, and wage earnings. Through questionnaire 4, expenditures on items such as clothing, household durables, education, health, housing, acquisition of physical assets, and credit were collected quarterly. Finally, a community-level questionnaire was completed to provide an explicit basis for ranking villages according to their degree of infrastructure development. In this questionnaire, the access of study villages to transport, communication, electricity, markets, cooperatives, banks, extension services, supply sources for modern inputs, schools, colleges, hospitals, and health centers was measured.

Because of the potential synergistic effects of the various elements that together constitute the complex set of infrastructure, a common index was constructed for all elements that could be used to rank villages to reflect their status of development. To place the 16 villages in the national perspective, the status of infrastructure development in rural Bangladesh is detailed next.

## Status of Rural Infrastructure (1980-82)

### Aggregate Data

In 1950/51, Bangladesh (then East Pakistan) had only 240 miles of hard-surfaced road, primarily in the cities of Dhaka, Chittagong, Khulna, and Rajshahi. The urban population was slightly less than 1 percent of total population (Pakistan, Central Statistical Office 1972). During the last three decades, Bangladesh has made modest progress in developing general infrastructure. This has occasionally touched on rural areas as an outgrowth of urban-oriented development. A picture of transportation infrastructure in rural areas in 1980/81 can be gleaned from Table 1. Hard-surfaced roads pass through 9 percent of the villages. An additional 12 percent of villages are located less than one mile from a hard-surfaced road. Forty percent of villages in Bangladesh are 5 miles or more away from a hard-surfaced road. About 20 percent are located more than 10 miles from an all-weather road. However, there are tremendous variations among districts. In 12 districts, more than 20 percent of villages are located more than 10 miles from roads. Density of good road is relatively high in Comilla, Tangail, Jessore, and Kushtia.

Access to transportation is a principal consideration, but it is not the only element that defines infrastructure. The status of development in some of the other elements of rural infrastructure is presented in Table 2. About one-fourth of the adult rural population can read and write. This level of adult literacy reflects the policy of providing extensive primary education through one school for about every two villages in the countryside. Every village possesses, on average, about 6 hand tubewells for supply of drinking water. One health center caters to health and medical services for every 20 villages. About 6 percent of the villages have access to electricity. There is one post office for every 10 villages, one primary market for every 4 villages, and one bank for every 25 villages. These indicators merely represent physical access; they do not

## Table 1—Access of villages to hard-surfaced roads, 1980/81

| District | Number of Villages | Percentage of Villages by Miles from Nearest Hard-Surfaced Road | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0[a] | Less Than 1 | 1–3 | 3–5 | 5–10 | More Than 10 |
| | | | | | (percent) | | |
| Chittagong | 1,664 | 16 | 14 | 20 | 12 | 15 | 23 |
| Chittagong Hill Tracts | 558 | 8 | 4 | 6 | 8 | 11 | 63 |
| Comilla | 5,853 | 11 | 14 | 23 | 18 | 25 | 9 |
| Noakhali | 2,132 | 10 | 15 | 26 | 18 | 20 | 11 |
| Sylhet | 10,189 | 9 | 14 | 22 | 15 | 19 | 21 |
| Dhaka | 8,061 | 6 | 12 | 18 | 14 | 23 | 27 |
| Faridpur | 6,128 | 3 | 7 | 13 | 11 | 20 | 46 |
| Jamalpur | 2,239 | 6 | 8 | 17 | 15 | 28 | 26 |
| Mymensingh | 7,063 | 8 | 13 | 19 | 16 | 17 | 27 |
| Tangail | 2,340 | 8 | 15 | 26 | 21 | 22 | 8 |
| Barisal | 2,762 | 7 | 9 | 18 | 15 | 24 | 27 |
| Jessore | 4,103 | 12 | 14 | 26 | 19 | 22 | 7 |
| Khulna | 3,680 | 16 | 14 | 17 | 11 | 18 | 24 |
| Kushtia | 1,609 | 14 | 13 | 29 | 20 | 20 | 4 |
| Patuakhali | 1,410 | 6 | 7 | 18 | 15 | 29 | 25 |
| Bogra | 3,813 | 12 | 14 | 24 | 16 | 22 | 12 |
| Dinagpur | 5,229 | 10 | 13 | 21 | 17 | 23 | 16 |
| Pabna | 3,913 | 8 | 14 | 21 | 13 | 25 | 19 |
| Rajshahi | 7,520 | 8 | 9 | 15 | 13 | 22 | 33 |
| Rangpur | 5,384 | 8 | 12 | 30 | 12 | 22 | 26 |
| Bangladesh | 85,650 | 9 | 12 | 24 | 15 | 21 | 19 |

Source: Bangladesh, Bureau of Statistics, *Socioeconomic Indicators of Bangladesh* (Dhaka: Ministry of Planning, 1985a).

[a] Village is located on road.

**Table 2—Extent of selected infrastructure facilities in rural areas of Bangladesh, 1980/81**

| Type | Average | Range Among Districts |
|---|---|---|
| Paved road (kilometers per 1,000-square-kilometer area) | 33.0 | 11 – 47 |
| Adult literacy (percent) | 23.4 | 17.2 – 33.2 |
| Rural water supply (number of tubewells per village) | 6.0 | 4.0 – 16.0 |
| Primary school (number per 100 villages) | 51.0 | 30.0 – 61.0 |
| Primary health centers (number per 100 villages) | 4.9 | 2.6 – 12.5 |
| Primary markets (number per 10 villages) | 2.7 | 0.8 – 3.5 |
| Electricity (proportion of villages) | 5.7 | 1.0 – 12.0 |
| Post office (number per 10 villages) | 0.8 | 0.1 – 1.2 |
| Banks (number per 100 villages)[a] | 4.0 | n.a. |
| Proportion of cultivated land under modern irrigation (percent) | 18.0 | 1.0 – 37.0 |

Source: Bangladesh, Bureau of Statistics, *Socioeconomic Indicators of Bangladesh* (Dhaka: 1985a).
Note: n.a. is not applicable.
[a] Includes specialized banks, such as the Agricultural Bank.

indicate how effective these accesses are in extending services to particular villages or classes of people within a village.

### Survey of 129 Villages

The state of rural infrastructure, as assessed through the 129-village survey, is determined by access to transport, markets, modern input supply systems, and social services.

*Access to Transport.* Access of villages to bus stations, inland water transport stations, and railway stations by various modes of transport, such as foot, bicycle, rickshaw, and boat, varies across the 129 villages. Table 3 shows the distribution of villages by distance from bus station and the primary modes of transport used to reach bus stations. Seven percent have a bus station in the village and another 18 percent are located less than one mile from a bus station. Walking, bicycles, and rickshaws are the primary modes of transportation from these villages to the bus station. About 37 percent of the villages are located five miles or more from the bus station. People walk or use small boats, launches or steamers, rickshaws, train service, or bicycles to travel from home to the bus station. About 10 percent of the villages report that no bus station is accessible, implying little or no use of bus services by these villagers. In all, 38 percent of villages report walking or cycling as the primary modes of transport to the bus station. Another 28 percent report rickshaws as the primary mode, and 17 percent use small boats.

About 83 percent of villages are located five miles or more from launch or steam stations (Table 4). About 60 percent of villages report that water-transport facilities, which are seasonal at best, are not accessible to them. About 61 percent of villages

## Table 3—Distribution of types of transport used for access to bus stations

| Distance to Bus | Foot or Bicycle | Rickshaw | Small Boat | Train | Steamer or Launch | Not Accessible | Total |
|---|---|---|---|---|---|---|---|
| | | | | (percent of villages) | | | |
| Station in village | 6.2 | 0.8 | 0.0 | 0.0 | 0.0 | . . . | 7.0 |
| Less than 1 mile | 13.2 | 3.1 | 0.8 | 0.0 | 0.8 | . . . | 17.9 |
| 1 – 3 miles | 10.8 | 13.9 | 2.3 | 0.0 | 0.0 | . . . | 27.0 |
| 3 – 5 miles | 3.9 | 4.6 | 2.3 | 0.0 | 0.0 | . . . | 10.8 |
| 5 – 10 miles | 3.1 | 3.9 | 8.5 | 0.0 | 0.0 | . . . | 15.5 |
| 10 miles or more | 0.8 | 1.3 | 3.1 | 2.3 | 4.6 | 9.7 | 21.8 |
| Total | 38.0 | 27.6 | 17.0 | 2.3 | 5.4 | 9.7 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

are located five miles or more from railway stations, and about 32 percent of villagers do not consider rail stations at all accessible to them. Again, the predominant modes of transport are foot or bicycle, rickshaw, bus, and boats for movement to railway stations.

*Access to Markets.* A primary market is a periodic market where buyers and sellers assemble generally once a week to trade agricultural products, products of rural industries, and other consumer goods. Sellers operate from mobile shops. The number of traders in such markets ranges from 500 to 2,000. A secondary market is larger than a primary market, and in contrast, businesses are housed in permanent structures, and transactions are daily. It is not uncommon for a secondary market also to function as a periodic market. Wholesale trade and stocking of goods are normal features of a secondary market.

Two types of banks usually operate in rural areas. Commercial banks accept deposits and advance loans. Specialized banks such as the Agricultural Development Bank generally advance loans only to farmers.

Access of villages to these markets and banks is analyzed in Table 4. About 71 percent of villages are within one mile of a primary market. Travel by foot, bicycle, rickshaw, and boat are the predominant modes of transport for participating in primary markets.

Access to secondary markets is obviously thinner than that to primary markets. About 20 percent of villages are located within one mile of a secondary market; about 27 percent are located five miles or more away. Within three miles, villagers go by foot, rickshaw, or cart, but as the distance increases, the use of boat, bus, and train services becomes more important for traveling to secondary markets. The 129-village survey indicates that there is about one bank for every 10 villages. There is a strong association between secondary markets and other services such as banks.

*Access to Modern Inputs and Electricity.* There are about nine fertilizer dealers per village in villages near the *upazila* headquarters. Similarly, villages with secondary markets have about three dealers per village. Away from *upazila* headquarters or secondary markets, the average number of fertilizer dealers is one per village, which means that there may be more than one dealer in one village, while a neighboring village may not (or need not) have any.

**Table 4—Access to infrastructure of 129 villages**

| Service | Miles to Service | | | | | |
|---|---|---|---|---|---|---|
| | 0[a] | Less Than 1 | 1–3 | 3–5 | 5–10 | 10 or More |
| | | | (percent of villages) | | | |
| Bus station | 7.0 | 17.9 | 27.0 | 10.8 | 15.5 | 21.8 |
| Train station | 2.3 | 8.6 | 14.7 | 13.1 | 11.7 | 49.6 |
| Launch/steamer station | 3.9 | 1.6 | 8.5 | 3.2 | 7.8 | 75.0 |
| Primary market | 31.0 | 40.3 | 20.3 | 6.2 | 2.3 | 0.0 |
| Secondary market | 7.8 | 11.7 | 23.9 | 29.4 | 22.4 | 4.7 |
| Bank | 10.9 | 20.2 | 39.6 | 16.2 | 12.4 | 0.8 |
| Post office | 24.0 | 33.4 | 34.1 | 6.9 | 1.6 | 0.0 |
| *Upazila* headquarters | 1.6 | 5.5 | 23.9 | 20.0 | 31.9 | 17.1 |
| Primary school | 68.0 | 25.8 | 6.2 | 0.0 | 0.0 | 0.0 |
| Secondary school, boys | 15.6 | 32.1 | 36.0 | 13.9 | 2.4 | 0.0 |
| Secondary school, girls | 7.8 | 11.7 | 21.0 | 18.7 | 21.0 | 19.8 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Service is located in the village.

Rural electricity is important for growth of rural processing industries and as an energy input to irrigation. Irrigation systems in Bangladesh consumed about 3 percent of the total electricity in the country in 1985 (Bangladesh, Bureau of Statistics 1985b). The sample survey indicates that about 33 percent of villages with primary markets, 60 percent with secondary markets, and 100 percent with *upazila* headquarters have electricity. However, as one moves away from these leading centers, the access of villages to electricity diminishes rapidly. Only 17 percent of the villages in the sample had access to electricity.

*Access to Social Services.* About 57 percent of the villages have a post office within one mile and 98 percent within five miles of the village (Table 4). And about 94 percent of the villages have a primary school within a mile. These two institutions are provided publicly under a policy of universal access. However, dispersion of secondary schools (for education up to the 10th or 12th grades) is thinner than that for primary schools. Only about 48 percent of villages have a secondary school within a one-mile distance. About 16 percent of villagers have to travel five miles or more to reach a secondary school. The situation is worse for girls than for boys. Only 19 percent of the villages have a girls' school within a one-mile distance. Girls are required to travel five miles or more to a secondary school in 42 percent of the villages.

## Infrastructure in 16 Study Villages and Their Ranking

Since the 16 study villages are a subset of the 129 villages surveyed earlier, a good deal has already been learned about their level of infrastructure development. These data indicate that the range is rather wide among villages in access to markets, financial institutions, transportation services, and sources of supply of modern agricultural inputs. Considering the plethora of infrastructural elements and their attributes described, an index is needed for each of the villages to rank them on a scale of infrastructure development.

## A Composite Measure of Infrastructure Development

A composite measure of infrastructure not only simplifies ranking the villages by reducing a large amount of data to a single measure, it also incorporates many qualitative aspects of infrastructure in a quantitative measure. This quantitative index is essential for capturing the full extent of the infrastructural effects in quantitative analysis. For example, a "distance" variable is frequently used, sometimes successfully and sometimes not, to measure the effect of infrastructure. A village may be located only 3 miles from a secondary market and yet access to the market may be more difficult than for a village located 10 miles away, if the latter has a better transport system. Each mode of transport—from walking to boarding a train or steamer—has different implications in monetary cost and time, which are determined not only by the condition of the road (paved, dirt, semipaved, and so forth) but also by other institutional factors. For example, in Comilla, where a cooperative institutional development initiated by the Comilla rural development academy operates, villages have a larger number of rickshaws and motorized transport vehicles per mile of roads than villages in Pabna, Dhaka, and Kushtia, even though agricultural production was not higher in Comilla's villages than in the others. Interaction of transport facilities with institutional infrastructures, including banks, public offices, and storage and sale centers for modern agricultural inputs, is considered quite important, although it cannot be captured by a distance variable. Certain indirect effects of infrastructure, such as spread of information and development of entrepreneurship among local residents, are by-products of interaction among various elements of what is broadly termed infrastructure. These effects are hard to incorporate in any analysis that does not develop an overall index for infrastructure development.

An infrastructure index of a village should reflect the diversity discussed above. The infrastructure index used in this paper is based on village-level information. Data include distances from the village to 13 elements of infrastructure, the principal means of transport used, and the cost per mile of travel. The 13 elements are the primary market, secondary market, primary school, secondary school (boys), secondary school (girls), college, post office, *upazila* center, bus stop, water transport station, rail station, bank, and union council office.

A total cost of access (TC) was computed by summing the individual costs of access ($IC_i$) of all 13 items. TC was then correlated with the costs for each element ($IC_i$), resulting in 13 correlation coefficients ($W_i$). The components with the highest W values selected are the primary market, secondary market, secondary school (boys), bank, bus stop, and *upazila* center.

The final index (INF) was then calculated by adding the six ICs, each weighted by their correlation coefficient ($W_i$) divided by the sum of the six correlation coefficients. The algebra of the formulation is shown below. This formulation was then used on data for the 16 villages to construct the infrastructure index.

$$IC_i = \text{distance} \times \text{cost per mile to element } i,$$

$$TC = \sum_{1}^{13} IC_i,$$

$$W_i = \text{correlation of } IC_i \text{ with } TC, \text{ and}$$

$$INF = \sum_{1}^{6} (W_i \times IC_i) / \sum_{1}^{6} W_i .$$

This procedure for measuring the degree of infrastructure development is comparable to the method developed by Sen (1980) for ranking countries by levels of economic development.[1]

### Selection Procedure and Logic

Why were 6 out of the 13 elements selected, what was the basis for this selection, and what theoretical reasoning can be offered for treating these elements as infrastructural variables? Of the 13 elements, union council offices (a union council is a political and administrative unit for 8-12 villages) and water transport stations are not permanent facilities. The union council office rotates among villages within a union when the chairman of the council changes. Water transport stations are seasonal and also move from location to location. Railway stations, girls' secondary schools, and colleges were rare in the 16 villages, although they did occur in the 129 villages. Since the government provides primary schools and post offices on the basis of universal coverage (a certain number for a fixed number of villages), they were not included because of the lack of variation. Moreover, it was assumed that post offices are not very important for rural development, and primary schools, though quite important, were proxied by the inclusion of secondary schools. That this pragmatic procedure is not likely to deviate widely from a systematic procedure is supported by a subsequent exercise using factor analysis techniques and presented in the Appendix, Table 63. This factor analysis also demonstrates that the weights used in the construction of the indices are not significantly different in order—though different in absolute magnitudes—from the weights (value of communality) that could be adopted from the factor analysis. The rank correlation between these two sets of weights is 0.87. This should not be a surprise because the correlation between TC and $IC_i$ is similar to a factor analysis where TC is the common factor and $IC_i$ are original variables.

The infrastructural variables that were collapsed into one index number represent access to transportation, markets, education, and public services such as agricultural extension, legal services, and so forth. Thus bus stations represent access to transportation, primary and secondary markets represent product markets, and banks represent the market for credit. An *upazila* center represents access to government services. The extension workers' offices and those of other government departments (including police) are located in the *upazila* center. That these infrastructural elements play a critical role in specialization, diffusion of technology, various social developments, development of markets, and entrepreneurial capacity has already been discussed in Chapter 2.

It is generally believed that the primary school is the most important educational factor for rural development. In both the correlation exercise and the factor analysis, the leading educational factor is found to be the secondary school. The rationale is as follows: Children who go to primary school but drop out after completing primary-level education are still too young to enter the labor force. Between the time when children drop out and when they enter the labor market, they are likely to forget whatever reading, writing, and arithmetic was learned, because skills are not applied and the learning process is discontinued for a long period. Primary school, on the other hand, is critical to acquiring a useful secondary education. It is a precondition for spreading secondary education among the widely dispersed rural population. In this sense, primary and secondary schools are inseparable if functional literacy among rural people is to be improved.

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[1] Sen's construction of indicators for ranking countries on a scale of economic development can be traced to a 1973 article, which was sharpened further for his 1980 comparative study of poverty. Essentially for weighting GNP, he assigns weighting vectors to different commodities. This weighting system is derived from linear transformation of the welfare function. It is true that Sen's indexes are endogenous and not used for exogenous purposes, but infrastructural indexes constructed in this study are used for explanatory purposes. In this sense, they are quite different. The lesson from Sen's approach that is relevant to this study is the concept that when many elements have interacting influences and contributions, they can often be collapsed into a single indicator or index. In his estimation of GNP, Sen adopts different treatments for military and police expenditures, environmental exhaustion, savings valuation, life expectancy, and income distribution than those usually used in national income accounting.

The weights ($w_i$) provided by the correlation and factor analysis indicate that private-sector activities—bus stations, markets, banks, and secondary schools—are leading infrastructural elements, and they are interrelated with various minor elements. This implies that development of roads by the government leads to the private sector taking the initiative for development of bus stations, banks, markets, and secondary schools. On the other hand, public-sector activities such as post offices and primary schools are provided on the principle of universal coverage, and therefore they are spread geographically beyond the main centers of commerce and transport. Thus, they are less correlated with other elements of infrastructure.

### Infrastructure Index

The degree of infrastructure development in 127 of the 129 villages is shown in Table 5. The names, ranking, and index numbers of the 16 villages are shown in Table 6. The index number indicates the degree of underdevelopment; the higher the value of the index number the less developed is the infrastructure. If the villages in the 129-village survey are classified into four groups: highly developed (less than or equal to 4.5), moderately developed (4.5 to 7.5), moderately underdeveloped (7.5 to 12.0), and highly underdeveloped (12.0 and above), then about 24 percent fall in the first category, 34 percent in the second, 25 percent in the third, and the remaining 17 percent in the highly underdeveloped category (Table 5). In the 16-village sample, 25 percent fall in the highly developed category and only about 6 percent in the highly underdeveloped (Table 6). It is apparent, however, that a strictly valid comparison between the two sets is difficult due to differences in sample size. It is nevertheless

**Table 5—Distribution of 127 villages among the ranges of the infrastructure index**

| Range of Index Numbers | Number of Villages | Percent of Total | Cumulative Percentage |
|---|---|---|---|
| 1.5–3.0 | 17 | 13.4 | 13.4 |
| 3.0–4.5 | 13 | 10.2 | 23.6 |
| 4.5–6.0 | 23 | 18.1 | 41.7 |
| 6.0–7.5 | 21 | 16.5 | 58.7 |
| 7.5–9.0 | 11 | 8.7 | 66.7 |
| 9.0–10.5 | 13 | 10.2 | 77.1 |
| 10.5–12.0 | 8 | 6.3 | 83.4 |
| 12.0–13.5 | 7 | 5.5 | 88.9 |
| 13.5–15.0 | 4 | 3.1 | 91.0 |
| 15.0–33.0 | 10 | 7.9 | 100.0 |
| Total | 127 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: The higher the index number, the less developed the infrastructure. Some values were missing in two villages; therefore 127 of the 129 villages were used in development of the index.

Table 6—Infrastructure index numbers of 16 study villages

| Rank/Village | Index Number |
|---|---|
| Developed | |
| Chasapara | 1.91 |
| Bandabeel | 2.88 |
| Illashpur | 3.92 |
| Patgari | 4.46 |
| Raokuli | 4.71 |
| Raotara | 4.71 |
| Khejurdanga | 5.37 |
| Underdeveloped | |
| Charkhamar | 6.47 |
| Khunta | 7.71 |
| Rajarampur | 9.52 |
| Taliamara | 9.63 |
| Gobrapara | 10.18 |
| Birhat | 10.19 |
| Syedpur | 10.69 |
| Harishpur | 11.09 |
| Gobindapur | 13.67 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.
Note: The higher the infrastructure index, the less developed the infrastructure.

clear that the 16-village sample represents somewhat better infrastructure than the sample of 129 villages.

In the remainder of this report, the effects of infrastructure are sometimes measured by comparing "developed" and "underdeveloped" villages and sometimes by using the infrastructure index or individual elements of the index in regression equations, depending on the nature of the analysis. In adopting the "developed" and "underdeveloped" dichotomy, the villages are divided into two groups above and below the average index. The villages with index numbers below the average are termed "developed" and those with index numbers above the average are termed "underdeveloped."

In some instances, results are presented that contrast the three most developed and the three least developed villages, which sharpens the contrast in results and is helpful in emphasizing certain effects of infrastructure development. This is particularly helpful in realizing the extent of benefits that the rural economy may derive from an investment designed to improve the infrastructural access of the most isolated villages to the level of the most developed villages in the sample.

## Some Structural Attributes of Households

Three basic characteristics of households—family size, size of landownership, and distribution of households within these groups—in developed and underdeveloped villages are presented in Tables 7 and 8. This information is critical to understanding many of the statistics pertaining to developed and underdeveloped villages and comparing household averages of income, investment, and so forth in developed and underdeveloped villages.

Data in Tables 7 and 8 support three principal conclusions. First, the average family size in developed villages is about 7 percent larger than that in underdeveloped villages.

### Table 7—Average family size and size of land owned by households in developed and underdeveloped villages, 1982

| Landownership Group | Developed | | Underdeveloped | | All Households | |
|---|---|---|---|---|---|---|
| | Land Owned | Family Size | Land Owned | Family Size | Land Owned | Family Size |
| | (acres) | (number) | (acres) | (number) | (acres) | (number) |
| Landless | 0.141 | 5.51 | 0.160 | 4.86 | 0.151 | 5.15 |
| Land owned | | | | | | |
| Small | 1.128 | 6.41 | 1.135 | 5.33 | 1.132 | 5.84 |
| Medium | 3.168 | 7.20 | 3.376 | 7.47 | 3.292 | 7.36 |
| Large | 7.564 | 9.86 | 9.256 | 8.71 | 8.683 | 9.10 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

Second, the average size of land owned is about 34 percent larger in underdeveloped areas than in developed areas. Thus, the land-person ratio is higher in underdeveloped than in developed villages. Third, the incidence of landless and small landowners is 9 to 15 percent higher in developed areas, whereas the incidence of medium and large owners is 12 to 34 percent higher in underdeveloped areas. This is to be expected because centers of infrastructure development attract population, so population density tends to increase with development.

### Table 8—Distribution of households by landownership groups in developed and underdeveloped villages

| Landownership Group | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|
| | | (percent) | |
| Landless | 31.9 | 29.4 | 8.5 |
| Land owned | | | |
| Small | 36.6 | 31.9 | 14.7 |
| Medium | 23.9 | 27.2 | −12.1 |
| Large | 7.6 | 11.5 | −33.9 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

# 4

# INFRASTRUCTURE AND AGRICULTURAL PRODUCTION

Underdevelopment of infrastructure affects the spatial variation of prices of agricultural products and inputs. To the extent that the demand for inputs is price elastic, underdevelopment directly affects the use of inputs, which in turn affects agricultural production. Moreover, some agricultural inputs may not even be available in some areas. Traders may not have enough incentive to move goods into those areas because transport costs are high and markets are thin due to low potential demand at high prices. Diffusion of modern technology in remote rural areas is constrained by infrastructural backwardness.

The other mechanism through which individual farmers can advance their earnings from farming is by producing an efficient combination of products, which is made possible by easy access to markets. The close proximity of farms to markets enables farmers to produce perishable products such as vegetables, fruits, and milk and bulky products such as sugarcane in order to sell them daily in the nearby markets. If immediate access to markets is not possible, perishable products will not be produced, which generally happens in infrastructurally backward areas.

Tracing the effects of the underdevelopment of infrastructure is done in three stages. First, the impact of infrastructure on price variation is assessed, and differences in prices in developed and underdeveloped areas are estimated. Second, demand functions are estimated for various agricultural inputs in order to study price responsiveness. Infrastructure is incorporated into the model as an additional explanatory variable to see whether availability is affected by infrastructure, independent of prices. The difference in input use in developed and underdeveloped areas is estimated from these models by applying the mean values of the exogenous variables. Third, the contribution of various inputs to production is derived by estimating a profit function and then assessing the impact of infrastructure on production by estimating the differences in production in developed and underdeveloped areas due to variation in the use of inputs. This profit function approach is expected to capture the contribution of infrastructure through improvements in efficiency in input and output combination. The overall impact of infrastructure on agricultural production represents the combined effect of resource use and efficiency.

## Infrastructure and Prices

In competitive markets, price variables are expected to be exogenous. The state of development of infrastructure, however, affects the transport costs and also the traders' margins, since the thinner the market, the higher the trade margin per unit needs to be to keep traders in business. The prices that farmers get include transport costs and traders' margins. Thus, farmgate prices may vary across farms, depending on the locations of consumers, farmers, and producers of agricultural inputs, as well as the state of development of infrastructure.

The following price equations are obtained from the survey data:

$$\mathrm{PRC_{Pd}} = \underset{(141.7)}{155.9} - \underset{(-0.53)}{0.0069}\,\mathrm{LNDO} - \underset{(-1.73)}{0.0112}\,\mathrm{PDDQ} - \underset{(-2.58)}{0.324}\,\mathrm{INF}; \tag{1}$$

$\bar{R}^2 = 0.03,\ F = 4.71;$

$$\mathrm{PRC_{R}} = \underset{(199.8)}{299.93} - \underset{(-4.52)}{0.814}\,\mathrm{LNDO} + \underset{(2.99)}{0.0264}\,\mathrm{PDDQ} - \underset{(-11.19)}{1.918}\,\mathrm{INF}; \tag{2}$$

$\bar{R}^2 = 0.25,\ F = 54.2;$

$$\mathrm{PRC_{F}} = \underset{(70.6)}{113.3} + \underset{(4.41)}{0.764}\,\mathrm{LNDO} - \underset{(-5.95)}{0.0142}\,\mathrm{FERTQ} - \underset{(11.77)}{2.166}\,\mathrm{INF}; \tag{3}$$

$\bar{R}^2 = 0.33,\ F = 79.6;$ and

$$\mathrm{WAGE} = \underset{(43.8)}{21.54} - \underset{(-2.28)}{0.133}\,\mathrm{LNDO} - \underset{(-7.65)}{0.0127}\,\mathrm{LBR} + \underset{(12.65)}{1.628}\,\mathrm{HYV} - \underset{(-4.36)}{0.239}\,\mathrm{INF}, \tag{4}$$

$\bar{R}^2 = 0.32,\ F = 57.4.$

The numbers in parentheses are estimated t-values. The definitions and measurements of the variables are as follows:

$PRC_{Pd}$ = the farmgate price of paddy in taka (TK) per maund (37.4 kilograms),
$PRC_{R}$ = the price of rice prevailing in the local market in taka per maund,
$PRC_{F}$ = the farmgate price of fertilizer in taka per maund,
WAGE = the wage rate paid by farmers per day of labor,
LNDO = the amount of land owned in acres,
PDDQ = the amount of paddy produced per household in maunds (37.4 kilograms),
FERTQ = the amount of fertilizer used per household in seers (0.935 kilogram),
LBR = the amount of labor used in crop production in number of days,
HYV = area cropped with high-yielding varieties of rice, in acres, and
INF = the index of underdevelopment of infrastructure.

The value of the adjusted $R^2$ is generally low, indicating the exogenous nature of prices. As can be noted from the estimates, the amount purchased is a significant determinant of the price of labor and fertilizer. Thus farmers who purchase in bulk pay lower prices for inputs. The size of land owned by the household is also found to influence prices—large landowners pay lower prices for labor but higher prices for fertilizer. That the large landowners pay higher prices for fertilizers is a counterintuitive result, but it should be noted that this effect of farm size is independent of the effect of scale economies of bulk purchases by large farms. The wage rate is found to be highly significantly related to the area sown in high-yielding varieties (HYVs) of rice. HYV area presumably affects the wage rate by increasing the demand for and the productivity of labor.

Large landowners and those who produce more obtain lower prices for paddy, as indicated by the negative coefficients of LNDO and PDDQ. However, the relationship is statistically very weak. The coefficient of PDDQ in the equation for rice prices is significantly positive, which is contrary to a priori expectations. Farmers usually sell their output in paddy form, and buy back rice when necessary. Those who produce large amounts of paddy presumably sell proportionately more coarse varieties than those who sell small amounts of paddy.

The index of the underdevelopment of infrastructure is found to be a highly significant variable, which explains variation in prices of fertilizer and labor even after the effect of the household-level variation in other variables is disassociated. The value of the infrastructure coefficient indicates that the price of fertilizer is higher in underdeveloped areas, whereas the wage rate is lower. This is to be expected because fertilizer is imported from outside the area, while labor is available locally. When infrastructure such as transportation and roads is underdeveloped, the mobility of labor is constrained; workers find it difficult to take advantage of demand for labor generated outside of their locality, which lowers the wage rate.

The effect of infrastructure on the price of paddy is much less pronounced than on the prices of fertilizer and labor. The value of $\bar{R}^2$ is quite low, although the regression coefficient is significantly different from zero. If infrastructure is underdeveloped, paddy prices in a village may be either high or low, depending on whether the village is a deficit or surplus paddy-growing area; hence, the effect of infrastructure on paddy prices is not unidirectional, which may explain the low value of $\bar{R}^2$. The effect of infrastructure is more significant in the case of rice than of paddy. Large-scale milling of rice, made possible by infrastructure development, makes the supply of rice cheaper and market arrival faster than under conditions of backward infrastructure. Hence, the effect of infrastructure on rice prices is likely to be significant. The values of the coefficients suggest that farmers are likely to get higher prices for rice and paddy with improvement in infrastructure.

What is the extent of the difference in prices between villages at the two ends of the scale of infrastructure development? In order to determine the magnitude of the price difference, the average values of the infrastructure index for three villages at each end of the scale are placed in the price equations and the prices are then estimated *at the mean values of the other variables.* The results are reported in Table 9. In developed villages the price of fertilizer is about 14 percent lower and the wage rate 12 percent higher than in underdeveloped villages. At 2 percent, the difference in the price of paddy is insignificant, but the price of rice is about 6 percent higher in developed villages.

## Demand for Inputs

The following input demand functions are postulated for fertilizer and labor:

$$\text{FERTQ} = f(\text{LNDCR, HYV, CPTL, CRDTI, CRDTNI, PRC}_F\text{, INF}), \text{ and} \qquad (5)$$

$$\text{LBR} = f(\text{LNDCR, HYV, CRDTI, CRDTNI, WAGE, INF}), \qquad (6)$$

### Table 9—Effect of infrastructure on agricultural prices, 1982

| Commodity/ Input | Developed Villages | Under-developed Villages | Difference[a] |
|---|---|---|---|
| | (Tk/maund) | | (percent) |
| Paddy | 154.07 | 151.19 | 1.9 |
| Rice | 293.80 | 276.73 | 6.2 |
| Fertilizer | 119.34 | 138.60 | −13.9 |
| Labor (Tk/day) | 20.19 | 18.06 | 11.8 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = |(Developed − Underdeveloped)/Underdeveloped| × 100.

where

LNDCR = the amount of land cropped by the household in acres;

CPTL = the value of nonland capital assets, measured in 1,000 taka;

CRDTI = the amount of credit received from institutional sources, measured in 1,000 taka;

CRDTNI = the amount of credit received from informal sources, measured in 1,000 taka,

and the other variables are defined as before.

The amount of inputs used by a household is assumed to be a function of the price of the input, of the amount of land cropped, and of the amount of area devoted to HYVs, since HYVs are both labor- and fertilizer-intensive, compared with traditional varieties. The amount of nonland assets owned by a household and the credit received from outside sources may also influence input demand by improving liquidity, making it possible to finance the use of optimal amounts of inputs. The effects of underdeveloped infrastructure may be captured indirectly through prices or, as will be argued later, through its effect on the adoption of technology. In addition, infrastructure may affect the availability of inputs. The infrastructure index is kept in the input demand functions to capture effects other than those on prices and technology.

The area devoted to HYVs depends on the state of development of infrastructure. Whether the farmer chooses to allocate land to the new crop varieties is largely determined by the availability of irrigation facilities. The choice may also depend on the effectiveness of extension agents, who spread knowledge about the new varieties and the agronomic practices that affect the productivity of inputs and the profitability of cultivation. The mobility of the extension agents may be constrained by poorly developed infrastructure. In that sense, the infrastructure index directly influences the allocation of land to HYVs and indirectly influences the demand for fertilizer and labor.

The development of irrigation facilities may also be a function of the state of development of infrastructure. In Bangladesh, irrigation facilities have been developed mostly by the government, mainly with external assistance. In the case of large-scale public projects implemented by the Water Development Board, the bias against the underdeveloped areas may be absent, since the entire command area has to be developed. But small-scale irrigation equipment such as pumps and tubewells tends to spread more quickly in the developed areas, where access to government officials in charge of the distribution of the equipment is easier. This is particularly true of tubewells, because underdeveloped infrastructure constrains movement of drilling equipment to interior areas. By 1984/85, modern irrigation facilities had spread to 1.71 million hectares of land (20 percent of cultivated area), of which only 9 percent was irrigated by canals, while 51 percent was irrigated by tubewells. Thus, by constraining the drilling of tubewells and the mobility of government officials, the underdevelopment of infrastructure may act as a significant determinant of the spatial distribution of irrigation facilities.

Agroclimatic and ecological conditions may also constrain the development of irrigation in certain areas. In the sample, 3 out of 16 villages are located in coastal areas, where salinity of water prohibits development of irrigation facilities and adoption of HYVs, which cannot tolerate saline water. Such agroclimatic factors also affect the demand for inputs. The following equations are postulated to explain the variation in the adoption of modern technology within the sample.

$$\mathrm{HYV} = f(\mathrm{IRGN}, \mathrm{LNDO}, \mathrm{CPTL}, \mathrm{CRDTI}, \mathrm{CRDTNI}, \mathrm{INF}), \text{ and} \tag{7}$$

$$\mathrm{IRGN} = f(\mathrm{LNDO}, \mathrm{CPTL}, \mathrm{DUMMY}, \mathrm{INF}), \tag{8}$$

where IRGN is the amount of owned land with access to irrigation facilities (in acres), and the DUMMY variable takes a value of one for villages located in the coastal area.

It was reported in the previous section that the prices of fertilizer and labor at the household level are to some extent determined by the amount of inputs purchased, although the correlation is weak. In order to make the price variable exogenous, the prices prevailing at the village level have been used in the input demand equations for households.

Since IRGN and HYV, which are endogenous variables, appear on the right-hand side of equations (10)-(12), this is a clear case of a simultaneous equation model with a recursive structure; irrigation determines HYV adoption, and HYV determines the demand for fertilizer and labor. The multiple equation estimator, using the three-stage least-square technique, appears to be appropriate. It explicitly permits contemporaneous correlation among disturbances in equations (7), (8), and (5) or (6). The estimates obtained by applying this method are as follows:

$$\begin{aligned}\mathrm{IRGN} = {} & \underset{(3.34)}{0.48} + \underset{(19.34)}{0.354}\,\mathrm{LNDO} - \underset{(-0.25)}{0.0013}\,\mathrm{CPTL} - \underset{(-4.58)}{0.84}\,\mathrm{DUMMY} \\ & - \underset{(-3.96)}{0.066}\,\mathrm{INF};\end{aligned} \tag{9}$$

$R^2 = 0.49$, $F = 107.8$;

$$\begin{aligned}\mathrm{HYV} = {} & \underset{(2.92)}{0.68} + \underset{(9.84)}{1.207}\,\mathrm{IRGN} - \underset{(-7.24)}{0.385}\,\mathrm{LNDO} - \underset{(-1.21)}{0.0091}\,\mathrm{CPTL} \\ & + \underset{(4.74)}{1.284}\,\mathrm{CRDTI} - \underset{(-1.30)}{0.085}\,\mathrm{CRDTNI} - \underset{(-0.42)}{1.17}\,\mathrm{INF};\end{aligned} \tag{10}$$

$R^2 = 0.51$, $F = 77.5$;

$$\begin{aligned}\mathrm{FERTQ} = {} & \underset{(2.82)}{113.87} + \underset{(1.51)}{1.713}\,\mathrm{LNDCR} + \underset{(21.55)}{124.2}\,\mathrm{HYV} - \underset{(-0.57)}{0.257}\,\mathrm{CPTL} \\ & + \underset{(3.38)}{45.66}\,\mathrm{CRDTI} + \underset{(0.78)}{0.249}\,\mathrm{CRDTNI} - \underset{(-2.31)}{0.748}\,\mathrm{PRC}_F - \underset{(-1.41)}{2.162}\,\mathrm{INF}; \end{aligned} \tag{11}$$

$R^2 = 0.50$, $F = 581.6$; and

$$\begin{aligned}\mathrm{LBR} = {} & \underset{(8.98)}{287.98} + \underset{(3.11)}{4.792}\,\mathrm{LNDCR} + \underset{(6.34)}{60.02}\,\mathrm{HYV} + \underset{(4.21)}{68.74}\,\mathrm{CRDTI} \\ & - \underset{(-3.54)}{14.60}\,\mathrm{CRDTNI} - \underset{(-7.70)}{11.75}\,\mathrm{WAGE} - \underset{(0.33)}{0.655}\,\mathrm{INF}; \end{aligned} \tag{12}$$

$R^2 = 0.55$, $F = 112.6$.

The values of $\bar{R}^2$ and F are from the ordinary least-square estimates.

The values of the coefficients of the price variables have the correct signs and are highly significant. The coefficients evaluated at the mean values of the variables give a price elasticity of demand for fertilizer of −0.55 and for labor of −1.33. Since these inputs are highly price responsive, and the infrastructure variable affects prices, it is apparent from the findings that infrastructure has an effect on production. The demand for fertilizer and labor are significantly and positively related to the availability of credit from institutional sources. Farmers' access to credit from formal sources depends on the spread of financial institutions (banks, cooperatives, and so forth), which are one of the elements of infrastructure. Also, establishment of financial institutions in an area often follows development of hard infrastructure, such as roads, and markets. In this sense, a credit-induced increase in the demand for inputs may also be partly attributed to development of infrastructure.

Infrastructure affects production through its impact on the adoption of HYVs. The availability of irrigation facilities is significantly inversely correlated with the state of underdevelopment of infrastructure, and irrigation is a major determinant of the adoption of HYVs. The value of the coefficient indicates that 1.0 additional acre of land under irrigation would increase the cropped area sown in HYVs by 1.2 acres. And the diffusion of HYVs increases the demand for fertilizer and labor.

The index indicates that the effects of infrastructure are primarily indirect, through prices and technology adoption. The direct effect, which is independent of prices and technology, is not significant. In the fertilizer demand equation, the value of the coefficient is negative, indicating lower fertilizer use in underdeveloped areas, but the coefficient is not significant. In the labor demand equation, the coefficient is positive but not statistically significant.

The differences in input use in villages at two ends of the scale of infrastructure development have been estimated from equations (9) through (12) by using the values of the infrastructure index for those areas and evaluating the exogenous variables at the arithmetic mean for the entire sample. The results are presented in Table 10. Due to the difference in the availability of irrigation, HYV adoption is about 71 percent higher in the developed villages. The difference in fertilizer use is also substantial—92 percent higher in developed villages than in underdeveloped. Lower fertilizer prices account for 12 percent of the difference, and higher rates of adoption of HYVs account

Table 10—Effect of infrastructure on the use of inputs

| Input | Unit | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | | | (percent) |
| Irrigation | Percent of owned land | 42.1 | 20.5 | 105 |
| Area sown in high-yielding varieties | Percent of cropped area | 42.0 | 24.5 | 71 |
| Fertilizer | Kilograms of material per hectare of cropped land | 150 | 78 | 92 |
| Labor | Days per hectare of cropped land | 119 | 115 | 4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

for 64 percent (Table 11). The difference in labor use is small, however—only 3.5 percent. This is because labor is locally available, and its price is lower in underdeveloped villages, which induces use of more labor in those areas. So, the infrastructure effect on the demand for labor through prices and availability of inputs is negative. The overall positive effect is due to higher rates of adoption of modern rice technology in developed villages. Labor use in developed villages is about 15 percent lower than in underdeveloped, due to the higher wage rate, but 22 percent higher due to more intensive adoption of rice HYVs.

## Tubewell Irrigation and Infrastructure

Although it is evident from the 16-village study that diffusion of irrigation-based modern technology in agriculture has been faster in infrastructurally developed than underdeveloped areas, the validity of generalizing this finding based on a sample of only 16 villages is questionable. Therefore, a full count of tubewells for irrigation was conducted in all villages of 10 *upazilas* where spread of tubewell irrigation is known to be extensive. The number of irrigation tubewells, their locations vis-à-vis roads, and their operational conditions were recorded through a census conducted in 1,609 villages in May and June of 1988. Using these data, the villages are grouped into three categories: (1) those that can be reached by a motorable road (a road traveled by cars, taxis, or three-wheeled vehicles called *tempos*) and that are less than five miles from an *upazila* headquarters (easy access); (2) those that can be reached by a motorable road but are five miles or more from an *upazila* headquarters (moderate access); and (3) those that cannot be reached by motorable road (difficult access). A village is considered to have access by a motorable road if the road passes through it or less than a mile away. The analysis of the diffusion of tubewell irrigation in these three categories of villages is shown in Table 12.

The table reveals a number of interesting interactions between rural infrastructure and diffusion of small-scale irrigation technology. First, villages with difficult access have achieved a much smaller rate of diffusion of tubewell-based irrigation technology than villages with easy or moderate access by motorable road. The proportion of villages with no tubewells is 7 percent in the easy-access group, 9 percent in the moderate-access group, and 28 percent in the difficult-access group. Second, the infrastructural factor

### Table 11—Differences in the use of fertilizer and labor as the result of infrastructure, developed and underdeveloped areas

| Input | Developed Versus Underdeveloped Area: Difference in Adoption of HYVs | Difference in Input Prices | Difference in Availability of Inputs | Total |
|---|---|---|---|---|
| | | (percent) | | |
| Fertilizer | 63.7 | 12.1 | 16.1 | 91.9 |
| Labor | 22.4 | −15.3 | −3.6 | 3.5 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: HYVs are high-yielding varieties.

influences not only the extent of diffusion but also the maintenance and use of tubewells. This is reflected in the proportion of tubewells that are in operating condition. About 97 percent of tubewells in the easy-access group are in operating condition, compared with 82 percent in the difficult-access group. The difference between the easy- and the moderate-access groups in this respect is small. Third, electrification of tubewells is five to seven times more extensive in the easy-access group than in the difficult-access group. Rural electrification generally expands along the routes of motorable roads, and this facilitates electrification in easy-access villages. Electrification of tubewells cuts operating costs by more than half. Moreover, management problems posed by transportation and storage of diesel oil in villages can be avoided by switching from diesel fuel to electricity for running tubewells.

The different rate of diffusion of deep and shallow tubewells in the three groups of villages supports the hypothesis that some public measures, though expensive, can help to overcome the constraints imposed by infrastructural backwardness. Deep tubewells are generally installed by public agencies, whereas the diffusion of shallow tubewells is left to private initiative. Diffusion of shallow tubewells in infrastructurally developed areas is more extensive than that in underdeveloped villages. Only 12 percent of villages in the easy-access group have no shallow tubewells, compared with

### Table 12—Diffusion of tubewell irrigation by degree of infrastructure development in 1,609 villages, 1988

| Degree of Accessibility of Village | Total Number of Villages | Villages without Deep Tubewells | Villages without Shallow Tubewells | Villages with No Tubewells | Tubewells Electrified: Deep | Tubewells Electrified: Shallow | Tubewells in Working Condition |
|---|---|---|---|---|---|---|---|
| | | | | (percent) | | | |
| Easy access | 648 | 60 | 12 | 7 | 14 | 5 | 97 |
| Moderate access | 466 | 61 | 15 | 9 | 10 | 3 | 95 |
| Difficult access | 495 | 70 | 29 | 28 | 2 | 1 | 82 |

Source: Computed from supplementary survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1988.

Notes: Villages with easy access are near a motorable road and within 5 miles of an *upazila* headquarters; villages with moderate access are near a motorable road, but more than 5 miles from an *upazila* headquarters; and those with difficult access are not accessible by a motorable road.

29 percent in the difficult-access group. In the case of deep tubewells, this difference still exists, but it is not as pronounced. Sixty percent of the villages in the easy-access group and 70 percent in the difficult-access group have no deep tubewells, a difference of 10 percentage points, compared with a difference of 17 percentage points between the two groups for shallow tubewells. This implies that a policy to encourage the private sector to initiate small-scale irrigation development—a policy thrust currently favored by donors and multilateral aid agencies—has a better chance of success where infrastructure is developed.

## Infrastructure and Efficiency of Resource Use

The relative economic efficiency of resource use in developed and underdeveloped areas can be studied by using the profit function approach suggested by Lau and Yotopoulos (1972). The profit function is derived from the application of the duality relation between the cost and the production function. The estimated parameters can be used to compare the technical efficiency and price efficiency of two groups of farms. For this purpose, farm households are divided into two groups, according to whether they are farming in infrastructurally developed or underdeveloped areas. The economic efficiency in the use of labor and fertilizer of the two groups is then compared.

In the model, farms are assumed to have fixed endowments of land, L, and capital, K, which cannot be varied in the short run. However, farms can choose variable amounts of labor, N, and fertilizer, F, the prices of which are W and C, respectively. The amounts of the variable inputs that the farm decides to use are determined by setting the marginal cost of the input, i, to $1/K_i$ times the marginal value product, where $K_i$ is the ratio by which the opportunity cost of the input to the farmer differs from market prices. Farms are called price efficient if all the capital inputs ($K_i$) are equal to unity. One farm may be more technically efficient than another if it produces a larger quantity of output from the same quantity of measurable inputs. Technical efficiency may differ between two groups of farms by a multiplicative factor. Differences in economic efficiency among groups of farms may be caused by differences in either technical or price efficiency.

Using the Cobb-Douglas assumption for technology, the model yields a unit output price (UOP) profit function,

$$\mathrm{Ln}\,\pi = \mathrm{Ln}A + \delta I + \alpha_1 \mathrm{Ln}W + \alpha_2 \mathrm{Ln}C + \beta_1 \mathrm{Ln}L + \beta_2 \mathrm{Ln}K, \qquad (13)$$

and two input demand equations:

$$-WN/\pi = \alpha_{11} I + \alpha_{12}(1 - I), \text{ and} \qquad (14)$$

$$-CF/\pi = \alpha_{21} I + \alpha_{22}(1 - I), \qquad (15)$$

where $\pi$ is the profit on the price of a unit output (gross revenue minus total variable cost), W and C are labor and fertilizer prices normalized by the output price, and I is a dummy variable taking a value of one for households operating in infrastructurally developed villages and zero for others.

The hypothesis of equal relative economic efficiency implies that $\delta$ is equal to zero. This hypothesis implies that $\alpha_{11} = \alpha_{12}$ and $\alpha_{21} = \alpha_{22}$. The hypothesis of absolute price efficiency implies that for farms in developed areas, $\alpha_{11} = \alpha_1$ and $\alpha_{21} = \alpha_2$, and the same holds true for farms in underdeveloped areas.

The error term is assumed to be additive, with an expectation of zero and finite variance for each of the three equations. But the covariances of the errors of either equation corresponding to different farms are both assumed to be zero. Under this specification of errors, Zellner's (1961) seemingly unrelated regression equation (SURE) provides an asymptotically efficient method of estimation, the efficiency of which can be increased by imposing known constraints on the coefficients in the equations.

In estimating the model from the data, profits are measured by deducting the costs of variable inputs—seed, fertilizer, manure, pesticides, irrigation, and labor—from the gross value of output. The cost of animal labor cannot be accounted for because data are not available, so animal labor is treated as a fixed input and included in farm capital. The cost of family labor is imputed from the wage rate paid to hired workers. The market for irrigation is imperfect, and the irrigation cost varied widely depending on the source of the supply of water. Since only the HYV crops are irrigated, the cost of irrigation is also imputed by multiplying the area under HYVs by the average cost of irrigation per unit of land for the entire sample. The farm-level prices of variable inputs can only be computed for labor and fertilizer, since quantity and cost information is only available for those two inputs. For this reason, only fertilizer and labor are used as variable inputs on the right-hand side of the profit equation. A significant proportion of farms did not hire labor or use chemical fertilizer, so prices cannot be computed for them. The average price of labor and fertilizer prevailing at the village level is used for these cases. The profit, wage rate, and fertilizer price variables are normalized by paddy prices. The capital input is measured in flow terms by multiplying the replacement cost of the stock of agricultural implements and draft animals with the rate of interest charged on loans from the commercial banks. Owing to widespread crop damage from natural calamities during the reference year of the survey, there were no profits—only losses—in a large number of cases (145 out of 475 farms in the sample). Because the UOP profit function is log linear, these cases are excluded. Since lower profits may also be due to inefficiency of resource use, this could introduce sample selection bias into the results.

A major criticism of the model is that the invariability of the prices in the cross-section data vitiates the usefulness of the methodology. This is not a serious problem for the data set used here. As already noted, the prices of labor and fertilizer across farms are significantly related to the state of underdevelopment of infrastructure. The coefficient of variation of prices across villages is 24 percent for labor, 14 percent for fertilizer, and 7 percent for paddy.

Zellner's (1961) seemingly unrelated regression method yields the following estimates of the profit function (equation 13) and the factor share equations (14 and 15) in the unrestricted form:

$$
\begin{array}{llllll}
\mathrm{Ln}\,\pi = & \underset{(-1.02)}{-0.399} & + \underset{(2.12)}{0.193\,\mathrm{I}} & - \underset{(-2.69)}{0.395\,\mathrm{LnW}} & - \underset{(-0.94)}{0.321\,\mathrm{LnC}} & \\
 & + \underset{(12.04)}{0.778\,\mathrm{LnL}} & + \underset{(4.77)}{0.130\,\mathrm{LnK}}; & & & (16)
\end{array}
$$

$\bar{R}^2 = 0.50$, $N = 330$;

$$WN/\pi = \underset{(-2.72)}{-0.659\,I} - \underset{(-5.36)}{1.120\,(1 - I)}; \text{ and} \qquad (17)$$

$$CF/\pi = \underset{(-3.74)}{-0.135\,I} - \underset{(-3.84)}{0.128\,(1 - I)}. \qquad (18)$$

The results of the tests of various hypotheses regarding the absolute and relative price efficiencies in the use of labor and fertilizer are presented in Table 13, as well as the constant returns to scale in production. The hypothesis that price efficiency is the same for farms in the developed and underdeveloped areas is accepted for fertilizer but is rejected for labor. Farmers in developed areas are relatively more price efficient in the use of labor than farmers in underdeveloped areas. Both groups are absolutely price efficient in the use of fertilizer, but only farmers in developed areas are absolutely price efficient in the use of labor. Presumably, farmers in underdeveloped villages have more surplus labor than those in developed villages because labor has more difficulty in taking advantage of employment opportunities outside the locality. Also, nonfarm employment opportunities are lower in underdeveloped villages. So farmers in these areas go on using family labor beyond the point in the production function where the marginal productivity of labor is equal to the wage rate. When the accepted hypotheses about price efficiency are maintained, the hypothesis of constant returns to scale is also accepted.

The estimate of the profit function under restriction of the parameters (for which the hypotheses are accepted) is as follows:

$$\begin{aligned} \mathrm{Ln}\,\pi = {} & \underset{(-4.09)}{-1.002} + \underset{(2.72)}{0.238\,I} - \underset{(-4.01)}{0.454\,\mathrm{Ln}W} - \underset{(-5.85)}{0.112\,\mathrm{Ln}C} \\ & + \underset{(32.9)}{0.879\,\mathrm{Ln}L} + \underset{(4.54)}{0.121\,\mathrm{Ln}K}. \qquad (19) \end{aligned}$$

Figures in parentheses are t-values. The value of the coefficient of infrastructure is found to be positive and statistically highly significant. It suggests that farms in developed areas are technically more efficient than their counterparts in underdeveloped areas, that is, they produce a larger quantity of output from the same amount of labor and fertilizer. This may be the result of a wider availability of irrigation facilities, higher rates of adoption of HYVs of rice, and better management in the developed villages, since it has already been shown that infrastructure affects input use and production indirectly through changes in technology and prices.

## Effects on Production

The parameters of the Cobb-Douglas production function can be derived indirectly from the profit function. The estimates are statistically more consistent than the parameters derived from direct estimates of the function, because it assumes all inputs to be exogenously determined, while in practice the level of use of variable inputs may be simultaneously determined depending on their prices, a maintained assumption of the profit function approach. Because $\alpha_1$ and $\alpha_2$ appear in the profit function as well as

## Table 13—Tests for hypotheses of relative and absolute price efficiency in the use of labor and fertilizer, and constant returns to scale

| Test | Parameter Restriction | Maintained Hypothesis | Value of Chi-square | Level of Significance |
|---|---|---|---|---|
| 1. Relative efficiency in the use of fertilizer | $\alpha_{21} = \alpha_{22}$ | none | 0.02 | 0.889 |
| 2. Relative efficiency in the use of labor | $\alpha_{11} = \alpha_{12}$ | none | 2.70 | 0.101 |
| 3. Absolute efficiency in the use of fertilizer | $\alpha_{22} = \alpha_2$,<br>$\alpha_{21} = \alpha_2$ | $\alpha_{11} = \alpha_1$ | 1.57 | 0.666 |
| 4. Absolute efficiency in the use of labor in developed areas | $\alpha_{11} = \alpha_1$ | none | 0.88 | 0.349 |
| 5. Absolute efficiency in the use of labor in underdeveloped areas | $\alpha_{12} = \alpha_1$ | $\alpha_{11} = \alpha_1$ | 9.08 | 0.011 |
| 6. Constant returns to scale | $\beta_1 + \beta_2 = 1$ | $\alpha_{11} = \alpha_1$<br>$\alpha_{21} = \alpha_2$<br>$\alpha_{22} = \alpha_2$ | 5.15 | 0.272 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

the respective factor share equations, imposing the restriction that they are equal in other equations improves the efficiency of the estimate.

Estimates of the output elasticities of the various inputs derived from equations (15) and (18) are presented in Table 14. The unrestricted function places the elasticity for labor at 0.23 and that for fertilizer at 0.19. When restrictions are imposed on the parameters, the elasticity for labor increases to 0.29, while that of fertilizer is reduced to 0.07. At the mean value of the variable, the marginal value product of labor is estimated at Tk 17.33 per day, which is about nine-tenths of the wage rate for hired labor. The marginal product of fertilizer is estimated at Tk 1.53 per taka of investment.

The effect of infrastructure on production can be estimated by applying the output elasticities to the difference in the use of labor and fertilizer in developed and underdeveloped villages (as reported in Table 10). If the parameters are taken from the unrestricted profit function, total crop production would be 18.0 percent higher in developed villages than in underdeveloped villages, but if the parameters are taken from the restricted profit function, the difference in production is reduced to 7.6 percent.

## Conclusions

Infrastructure affects agricultural production indirectly through prices, diffusion of technology, and the use of inputs. In this chapter, a multivariate regression technique was used to isolate the effect of infrastructure on these variables, after taking into account the effects of other exogenous factors. The price of the major output, paddy, does not differ much across villages at different levels of infrastructure, but the price of fertilizer is 14 percent lower and that of labor 12 percent higher in villages with more developed infrastructural facilities. The difference in area covered by irrigation and HYVs of rice between the two groups of villages is found to be 105 percent and 71 percent, respectively.

## Table 14—Indirect estimates of the output elasticities of various inputs and the marginal value products

| Inputs | Output Elasticity | | Marginal Value Product | | | Price of the Input |
|---|---|---|---|---|---|---|
| | Unrestricted Function | Restricted Function | Unit | Unrestricted Function | Restricted Function | |
| Fixed | | | | | | |
| Land | 0.454 | 0.561 | acre | 2,426 | 2,998 | 2,878 |
| Capital | 0.076 | 0.077 | Tk | 1.34 | 1.35 | 1.00 |
| Variable | | | | | | |
| Labor | 0.230 | 0.290 | day | 13.74 | 17.33 | 19.54 |
| Fertilizer | 0.187 | 0.072 | Tk | 3.97 | 1.53 | 1.00 |
| Sum of elasticities | 1.000 | | | | | |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Differences in the adoption of the new technology and prices were incorporated into the input demand functions to estimate the effect on the use of fertilizer and labor. The result suggests that there is little impact on the use of labor, but use of fertilizer is 92 percent higher in the developed villages. The estimate of the production function suggests that these effects on input demand increase production in the developed villages about 8 percent. In addition, developed villages produce about 24 percent more than underdeveloped villages, due to more efficient use of the inputs allowed by the improved production technology. The analysis thus suggests that the differences in the composition and levels of infrastructure prevailing in the two groups of villages may account for about 32 percent difference in crop output produced between these areas.

## 5

# INFRASTRUCTURE, THE RURAL LABOR MARKET, AND EMPLOYMENT

Infrastructure affects the rural labor market and employment in several ways. First, it may influence the supply of labor by inducing laborers to work harder. According to standard economic theory, the choice between labor and leisure is determined by the cost of leisure (in wage income) relative to the prices of consumer goods that can be bought with income from labor. The state of development of infrastructure determines the availability of consumer goods produced outside the locality and their prices. High unit transport costs may inhibit the movement of some goods into interior areas; since consumer prices include transport costs, prices may be so high that the potential demand for the goods may be too low to warrant transporting them. Therefore, in underdeveloped areas some goods may not be available at all, or their prices may be so high that the incentive to earn more by working more is dampened.

Second, infrastructure development may improve the efficiency of the labor market. Underdeveloped infrastructure affects the wage rate by constraining the mobility of workers. Shortages and surpluses of labor in the market can be overcome through migration of workers, and migration tends to equalize the wage rate over a wider area. Underdevelopment of infrastructure, however, limits the size of the area over which labor is mobile and hence contributes to the fragmentation of the labor market. Thus, shortages and surpluses of labor can coexist with wide variation in wage rates and inefficient use of labor. By affecting the wage rate, infrastructure influences the choice between labor and leisure and between self-employment and wage employment.

Third, positive effects of infrastructure development on agriculture, industry, and services imply a positive effect on the demand for labor. Some elements of infrastructure, such as availability of electrical power and access to financial institutions, may determine the location of certain skill-intensive nonfarm activities, the development of which would increase labor productivity and employment. This induces more investment in formation of human capital (education and training) and increases the productivity of employment. Apart from these indirect effects, the development of infrastructure has a significant impact on employment in services and transport.

The objective of this chapter is to assess the effects of infrastructure on employment by estimating the supply of and demand for labor in the 16-village sample by incorporating infrastructure as an explanatory variable. Information on the supply of labor was collected from all members of the sample households who participated in income-earning activities by asking about their allocation of time each day of the week preceding the day of the interview for eight weeks scattered throughout the year 1982. The periods were selected on the basis of a prior knowledge of the cropping pattern of the area so as to represent normal, busy, and slack periods of employment. The supply of labor for the whole year and the composition of employment is estimated by extrapolating the data for eight weeks. The information on demand for labor is only available for crop production activities. It is estimated from the use of labor for different crops grown by the sample farmers during 1982, the information on which was collected through three rounds of interviews conducted at the end of each of the three crop seasons (boro, aus, and aman) during the year.

## Infrastructure and Employment: A Descriptive Profile

This section provides a broad overview of the supply and demand for labor and the importance of the labor market in the two groups of villages that have already been classified on the basis of the state of infrastructure development. The methods used to construct the composite index of underdevelopment of infrastructure for the 16 villages were discussed in Chapter 3. The developed area consists of villages with index values lower than the mean for the entire sample; the remaining villages constitute the underdeveloped area. Employment also affects a host of other factors besides infrastructure, but in the descriptive analysis presented here, it is not possible to control for the effects of all such variables. This is attempted in a subsequent section. Because landownership affects labor and employment profoundly, the results are presented separately for four groups: (1) the landless, defined as households owning less than 0.5 acre; (2) small owners, with up to 2 acres; (3) middle-size owners, with 2-5 acres; and (4) large owners, with more than 5 acres. This classification also makes it easier to understand the behavior of different socioeconomic groups in the villages.

### Supply of Workers

For the purposes of this study, a worker is defined as a person who was available for work in an income-earning activity during any of the eight weeks included in the survey. On this basis, the proportion of the population in the sample participating in the labor force is estimated at 29.7 percent, compared with 29.4 percent for the country as a whole, as estimated by the Employment and Labor Force Survey of 1983/84 (Bangladesh, Bureau of Statistics 1986).

The rate of participation in the underdeveloped and developed villages can be seen in Table 15. There is no marked difference between the two groups in labor force participation. The rate is found to be inversely related to the size of landholding. In the underdeveloped villages nearly 33 percent of the population in the landless households participated in the labor force, compared with only 25 percent in the large landowning households. Since income is highly and positively associated with the size of land owned, this suggests that the higher income households supply fewer workers,

**Table 15—Participation in income-earning activities in developed and underdeveloped villages, 1982**

| Landownership Group | Workers as a Percent of Family Members | | | Female Workers as a Percent of Total Workers | | |
|---|---|---|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Difference | Underdeveloped Villages | Developed Villages | Difference |
| Landless | 32.9 | 33.1 | 0.2 | 10.1 | 21.8 | 11.7 |
| Land owned | | | | | | |
| Small | 30.8 | 29.1 | -1.7 | 8.5 | 14.4 | 5.9 |
| Medium | 27.9 | 29.0 | 1.1 | 3.0 | 10.7 | 7.7 |
| Large | 25.4 | 28.8 | 3.4 | 2.3 | 10.1 | 7.8 |
| All households | 29.3 | 30.1 | 0.8 | 6.4 | 15.1 | 8.7 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

an indication of a greater preference for leisure over work. Another explanation for the lower labor force participation in higher-income groups is the higher rate of school attendance by children. In the developed villages, the participation rate also declines as the size of landholding increases, but the difference is much less accentuated. In the underdeveloped villages, the large landowning households supply 23 percent fewer workers to the labor force than do the landless households, whereas the difference narrows to 13 percent in the developed villages. The landowning households with medium or large holdings are more likely to participate in economic activities in developed than in underdeveloped villages.

A large part of the increase in the supply of workers in the developed villages is due to higher participation of women in economic activities (15.1 percent, compared with 6.4 percent) in the underdeveloped villages. The proportion of female workers declines sharply as the size of land owned increases, participation being negligible among the middle-size and large landowning households. With development of infrastructure facilities, female participation increases irrespective of the landownership group, the rate of increase being relatively higher among large landowning households. For the middle-size and large landowning households the proportion of female workers is about 10 percent in developed villages and less than 3 percent in underdeveloped villages; for the landless group the figures are 22 and 10 percent, respectively.

In Bangladesh there is a social stigma against women working in the field or performing manual labor on another's account. However, under the pressure of poverty, women from very poor families try to earn income or reduce spending by organizing production activities around the homestead. Nearly two-thirds of the workers engaged in cottage industries are women. A significant number of women are coming forward to take loans from credit institutions to set themselves up in livestock and poultry raising, processing, or manufacturing. The development of infrastructure provides additional scope for undertaking such activities and increases labor force participation among women from poor households. In the upper-income groups, women having high school educations do not participate in the labor force due to lack of suitable employment. Schools, financial institutions, and government offices, which are concentrated in areas where infrastructure is highly developed, provide employment for educated women in the nonagricultural sector.

## The Labor Supply and Its Composition

Since the number of hours of labor put in by a worker during a day may vary across villages, and a worker may be engaged in a number of activities during a day, engagement in productive work was recorded in the survey by hours of activity for each worker belonging to a sample household. The estimate of the supply of labor at the individual worker and household level is constructed from these data. First, average weekly labor hours for the eight weeks of the survey are measured for each activity and sector and multiplied by 52 to estimate the supply of labor in 1982. This figure is then converted into standard eight-hour person-days. The number of days of labor put in by an average worker is about 254 standard eight-hour person-days or 39 hours per week (Table 16).

Days of labor are found to be inversely related to the size of land owned (Table 16), again suggesting that at higher levels of income people substitute leisure for labor. In the underdeveloped villages, a worker in the large landownership group puts in 229 days of labor, compared with 265 days for a worker in the landless group—about 14 percent fewer days. In the infrastructurally developed villages, the difference is even more pronounced—the landless work about 4 percent more and the large landowners 7 percent less than in the underdeveloped villages. There is no significant difference

## Table 16—Days of labor in developed and underdeveloped villages, 1982

| Landownership Group | Days of Employment/Worker | | | Days of Employment/Household | | |
|---|---|---|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Difference | Underdeveloped Villages | Developed Villages | Difference |
| | | | (percent) | | | (percent) |
| Landless | 265 | 276 | 4.2 | 425 | 501 | 17.9 |
| Land owned | | | | | | |
| Small | 264 | 257 | −2.7 | 435 | 480 | 10.3 |
| Medium | 241 | 241 | . . . | 501 | 503 | 0.4 |
| Large | 229 | 212 | −7.4 | 504 | 585 | 16.1 |
| All households | 254 | 253 | . . . | 457 | 502 | 9.9 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more. The ellipses (. . .) indicate a nil or negligible amount.

in the supply of labor *per worker* between the developed and underdeveloped villages, but the labor supplied per household is about 10 percent higher in the developed villages because family sizes are larger and more members participate in the labor force. This difference is pronounced for the landless and large landowning households, whereas it is insignificant for the middle landownership group.

The impact of infrastructure is stronger in the sectoral composition of the labor supply (Table 17). Labor supply in agriculture increases with the size of landholding, since land provides the opportunity for family workers to be self-employed. But the landowning households supply less labor for agriculture in the developed villages, and the landless households supply about one-third more. It appears that as nonagricultural employment opportunities are generated following the development of infrastructure, people tend to substitute relatively more productive nonagricultural labor for arduous agricultural labor. This generates more employment opportunities for the landless in agriculture.

Since the landless often cannot find enough employment on the land, they are more likely than other groups to engage in nonagricultural activities. In underdeveloped villages, about 55 percent of the labor supply in landless households works in nonagricultural activities compared with only 18 percent in the large landowner households. In developed villages the picture is different. With development of infrastructure, the share of nonagricultural laborers in the total labor supply declines to one-half for the landless, while it increases to nearly one-third for the large landowner households.

For all households, the supply of labor in nonagriculture is about 30 percent higher in developed villages than in the underdeveloped ones, suggesting that development of infrastructure increases the opportunity for nonagricultural employment. But the higher income groups are more likely to take the opportunity.

Even self-employment in some nonagricultural activities requires investment in working capital and some basic skills like functional literacy and numeracy. Widespread illiteracy and lack of access to financial institutions may constrain the poor from taking up nonagricultural employment. Thus, the landless are more likely to engage in manual, labor-intensive nonfarm activities, where labor productivity is low. As development of infrastructure creates opportunities for nonfarm jobs with higher productivity, luring

## Table 17—Sectoral composition of employment in developed and underdeveloped villages, 1982

| Landownership Group | Agricultural Labor | | | Nonagricultural Labor | | |
|---|---|---|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Difference | Underdeveloped Villages | Developed Villages | Difference |
| | (days/household) | | (percent) | (days/household) | | (percent) |
| Landless | 189 | 251 | 32.8 | 235 | 250 | 6.4 |
| Land owned | | | | | | |
| Small | 276 | 267 | −3.3 | 159 | 213 | 34.0 |
| Medium | 391 | 340 | −13.0 | 110 | 163 | 48.2 |
| Large | 414 | 400 | −3.4 | 89 | 185 | 107.9 |
| All households | 297 | 292 | −1.7 | 161 | 210 | 30.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

the higher-income groups with capital and skills, more agricultural jobs become available to the landless, who can then afford to give up the nonfarm jobs with low productivity.

A detailed breakdown of the labor supply by activity in developed and underdeveloped villages is provided in Table 18. In developed villages, the supply of family labor to crop production is about one-fifth less and the supply of wage labor is about two-thirds more than in underdeveloped villages. The supply of wage labor is provided mostly by the landless and marginal landowning groups. As the demand for hired labor increases to compensate for the decline in the supply of family labor in crop production activity, the labor supply declines in earthwork and miscellaneous activities, which are undertaken mostly by the poor as distress employment. The activities that show an increase in the labor supply with development of infrastructure facilities are construction and transport, other services, and cottage industries, which are mostly skill- or capital-intensive. It may be surprising that the supply of labor in trading activities does not respond to the development of infrastructure. While the volume of trade may increase, petty trade, which is the dominant mode of transaction in interior areas due to lack of transport facilities, presumably gives way to more organized commercial trading as the transport sector develops. The increase in productivity reduces the demand for labor in trading activities.

### Supply of Labor to the Market

In Bangladesh, the size of the rural labor market is small. During the survey year the sample households supplied only 32 percent of the total supply as wage labor, 22 percent in agricultural activities, and 49 percent in nonagricultural activities. This is not surprising in view of the small average size of farm holdings, most of which are incapable of generating full employment for family workers. In fact, labor is hired in crop production mainly because of the highly seasonal nature of operations, which creates occasional shortages of labor, although family workers belonging to large farm households may remain considerably underemployed at other times of the year and may have to look for nonagricultural occupations. Many agricultural households generate nonfarm employment on their own account in response to the lack of adequate employment in crop production activities.

## Table 18—Supply of labor in developed and underdeveloped villages by activity, 1982

| Activity | Percent of Households Participating in Activity | | Employment/Participating Household | | Employment/Household[a] | | |
|---|---|---|---|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Underdeveloped Villages | Developed Villages | Underdeveloped Villages | Developed Villages | Difference |
| | | | (days) | | (days) | | (percent) |
| Agriculture | | | | | | | |
| Cultivating family farm | 85.9 | 74.1 | 234 | 209 | 201 | 155 | −22.9 |
| Agricultural wage labor | 40.1 | 46.1 | 124 | 181 | 50 | 84 | 68.0 |
| Livestock raising | 49.4 | 44.2 | 58 | 60 | 29 | 27 | −6.9 |
| Fishing | 28.6 | 17.4 | 60 | 180 | 17 | 31 | 82.4 |
| Nonagriculture | | | | | | | |
| Cottage industry | 7.9 | 12.2 | 120 | 143 | 10 | 18 | 44.4 |
| Trade and shopkeeping | 33.6 | 22.3 | 131 | 189 | 44 | 42 | −5.5 |
| Construction and transport | 34.5 | 46.4 | 71 | 161 | 24 | 75 | 212.5 |
| Services | 22.3 | 40.3 | 141 | 142 | 32 | 57 | 78.1 |
| Earthwork | 28.0 | 11.5 | 102 | 63 | 28 | 7 | −75.0 |
| Miscellaneous activities | 59.1 | 38.1 | 39 | 28 | 23 | 11 | −52.2 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Includes all households in sample.

Data comparing the supply of hired labor in the developed and underdeveloped villages suggest that the development of infrastructure expands the size of the labor market (Table 19). In the developed villages, an average household supplied 198 days of labor outside the family, compared with 121 days in underdeveloped villages, a difference of about 64 percent. The landless households supply more labor to the market than the landowning households because land provides opportunities for generating self-employment. In the underdeveloped villages, the landless supplied about 52 percent of the labor to the market, compared with only 5 percent for the large landowning households. In developed villages all landownership groups supplied more labor to the market than they did in underdeveloped villages, but the absolute difference is highest for the landless and small landowning households. It appears that as infrastructure develops, the higher-income groups substitute self-employment on land for nonfarm jobs, creating more opportunities for hired agricultural employment for the lower-income groups, who in turn substitute agricultural wage employment for low-production, nonfarm self-employment.

### Demand for Agricultural Labor

The information obtained from farm households on the use of labor in crop productivity is shown in Table 20. The average size of holding is significantly different for the two areas, particularly for the large landownership group. Since this affects the demand for labor at the household level, the information on labor use is standardized by expressing it per unit of cropped land. Total labor use is 12 percent higher in

## Table 19—Supply of labor to the market by landownership group, 1982

| Landownership Group | Days of Hired-Out Labor/Household: Underdeveloped Villages | Days of Hired-Out Labor/Household: Developed Villages | Days of Hired-Out Labor/Household: Difference | Hired-Out Labor as a Percent of Total Labor Supply: Underdeveloped Villages | Hired-Out Labor as a Percent of Total Labor Supply: Developed Villages |
|---|---|---|---|---|---|
| Landless | 224 | 311 | 87 | 52.7 | 62.1 |
| Land owned | | | | | |
| Small | 116 | 200 | 84 | 26.7 | 41.7 |
| Medium | 52 | 107 | 55 | 10.4 | 21.3 |
| Large | 26 | 39 | 13 | 5.2 | 6.7 |
| All households | 121 | 198 | 77 | 26.5 | 39.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

developed than in underdeveloped villages, primarily due to higher levels of adoption of modern rice technology, which is more labor-intensive. But the rate of increase is proportionately much higher for hired labor than for family labor. In developed villages the use of hired labor is about 16 percent higher than in underdeveloped villages, while the use of family labor is only 9 percent higher. This information also supports the contention that as infrastructure develops, self-employment in agriculture gives way to wage employment.

An interesting point to be noted in Table 20 is that the higher labor use in crop production in developed villages is mainly on account of small and middle-size farms. Compared with underdeveloped villages, labor use in developed villages is about 12 percent higher for small farms, 18 percent higher for the middle-size farms, and less than 2 percent higher for large farms. In fact, large farms in developed villages use more family labor and less hired labor than those in underdeveloped villages. This pattern of behavior is difficult to explain. But the effect of farm size on demand for labor may partly explain this result. The average farm areas in all size groups, particularly the large, were higher in underdeveloped than developed villages. It appears that when there is an increase in the demand for hired labor among all groups of farm households,

## Table 20—Demand for labor for crop production in developed and underdeveloped villages, 1982

| Size of Farm | Family Labor: Underdeveloped Villages | Family Labor: Developed Villages | Hired Labor: Underdeveloped Villages | Hired Labor: Developed Villages | Total Labor: Underdeveloped Villages | Total Labor: Developed Villages |
|---|---|---|---|---|---|---|
| (acres) | | | (days/acre of cropped land) | | | |
| Small (up to 2) | 38.0 | 39.1 | 16.4 | 22.0 | 54.4 | 61.1 |
| Medium (2 – 5) | 25.8 | 27.1 | 16.5 | 22.7 | 42.3 | 49.8 |
| Large (more than 5) | 19.4 | 23.6 | 31.1 | 27.7 | 50.5 | 51.3 |
| All farm households | 27.1 | 29.6 | 20.8 | 24.1 | 47.9 | 53.7 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

the large farmers suffer more during the seasonal period of labor scarcity because of the higher absolute amount of labor that they need. They may respond by allocating more land to less labor-intensive crops or by using more family labor. Indeed, the same data show that the larger farms devote proportionately less land to labor-intensive modern varieties of rice and that many large landowners grow these crops through labor-surplus tenant farmers (Hossain 1988b).

## Infrastructure and Operation of the Labor Market

In this section a multivariate analysis of the determinants of the supply of and demand for labor is attempted in order to assess precisely the impact of development of infrastructure on the rural labor market. The market may be affected by a host of factors that are exogenous to infrastructure. In assessing the effects of infrastructure, the effects of the other variables should be controlled for, which could not be done in the descriptive analysis.

### Determinants of the Labor Supply

According to standard economic theory, the supply of labor is mainly determined by the price of leisure relative to the prices of consumer goods. However, the supply may vary according to the age-sex characteristics of the workers because these influence the time available for labor, and also according to the number of dependents per earner in the household because all members of the household share in the earnings. The possibility for earnings from nonlabor sources shifts the supply curve. Ownership of land and nonland fixed assets provides the scope for such earnings. Also, the higher the level of education of the worker, the higher the productivity of labor and the greater the possibility of moving to a higher-income job. The following supply function for labor is postulated:

$$SLBR = f(WAGE, WRKR, FEM, FSZ, LAND, HYV, CPTL, EDCN, LVNG, INF),$$

where

SLBR = the number of days of labor supplied by the household during the survey year,

WAGE = the wage rate prevailing in the village during the year of survey, measured in taka per day,

WRKR = the number of members who participated in income-earning activity during any of the eight weeks of the survey,

FEM = the number of female workers,

FSZ = the number of household members,

LAND = land owned by the household in acres,

HYV = land cropped with modern varieties of rice,

CPTL = the value of nonland fixed assets owned by the household, in 1,000 taka,

EDCN = the number of years of formal schooling for the head of the household,

LVNG = the standard of living in the village, as measured by the per capita consumption expenditure per year in 100 taka, and

INF = the index of underdevelopment of infrastructure.

The standard-of-living variable is included to capture the effect of poverty in the village on the labor-leisure choice of its members. The wage rate is measured at the village level because it is more exogenous than the variable measured at the household level, which may be somewhat influenced by the endowment of land and workers in the household. The wage rate, the level of per capita consumption in the village, and the extent of adoption of modern varieties may be influenced by the state of underdevelopment of infrastructure. In order to see if correlation among these variables affects the results significantly, stepwise regressions are also run to exclude these variables from the functions.

The estimated supply function including all of the above variables at the household level is presented in Table 21. Nearly two-thirds of the variation in labor supply across households is explained by the variables included in the model. The results of the stepwise regression show that exclusion of the wage rate, standard of living, and adoption of new technology variables significantly reduces the value of the adjusted $R^2$, while the coefficient of the infrastructure variable does not change significantly. Therefore, it may be more appropriate to interpret the results for the equation that incorporates all the variables.

The results show that as income from nonlabor sources increases, rural households tend to supply less labor. This is indicated by the negative coefficients of the standard of living in the village, the amount of land owned by the village, the adoption of the new technology, and the level of education. For example, the value of the coefficients

### Table 21—Estimates of supply function for labor, all activities

| Variable | Estimate 1 |  | Estimate 2 |  | Estimate 3 |  |
|---|---|---|---|---|---|---|
|  | Coefficient | t-Value | Coefficient | t-Value | Coefficient | t-Value |
| Constant | 193.0 | 3.75*** | 17.4 | 1.48 | 64.5 | 2.74*** |
| Number of workers | 201.2 | 27.50*** | 196.5 | 25.80*** | 195.6 | 25.75*** |
| Number of female workers | −70.3 | −4.49*** | −33.9 | −2.15** | −35.2 | −2.24*** |
| Family size | 8.6 | 3.44*** | 8.6 | 3.32** | 8.7 | 3.36*** |
| Land owned | −7.6 | −2.94*** | −11.1 | −4.31*** | −11.6 | −4.52*** |
| Land sown in high-yielding varieties | −13.3 | −2.75*** | n.a. | n.a. | n.a. | n.a. |
| Capital | 2.3 | 3.96*** | 2.1 | 3.42*** | 2.1 | 3.53*** |
| Education of the household head | −4.1 | −2.28*** | −4.3 | −2.30*** | 4.0 | 3.36*** |
| Wage rate | 7.37 | 4.80*** | 2.1 | 1.48 | n.a. | n.a. |
| Consumption level of the village | −9.65 | −6.56*** | n.a. | n.a. | n.a. | n.a. |
| Index of underdevelopment of infrastructure | 2.08 | 1.06 | 2.79 | 1.38 | 2.19 | 1.10 |
| $\bar{R}^2$ | 0.67 | n.a. | 0.63 | n.a. | 0.63 | n.a. |
| F | 152.70 | n.a. | 135.58 | n.a. | 154.40 | n.a. |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: n.a. is not applicable.

**Significant at the 0.05 level.

***Significant at the 0.01 level.

of the land variable suggests that each additional acre of land owned by a household would reduce the supply of labor by 8 days, and if that land is sown in HYVs of rice, the labor supply would be reduced by 21 days. Only the ownership of nonland capital assets seems to increase the supply of labor, presumably because it helps to generate additional self-employment.

Household composition also seems to affect the labor supply significantly. A positive coefficient of family size indicates that the larger the number of dependents per earner, the more days of work are necessary. Each additional earner in a household increases the labor supply by 201 days. A female, however, works about 70 days less than a male.

The labor supply is positively associated with the wage rate. An increase in the wage rate of Tk 1.00 on the margin increases the supply of labor by seven days. Since underdevelopment of infrastructure reduces the wage rate, which in turn reduces the supply of labor, earnings from labor tend to be less in villages with underdeveloped infrastructure facilities.

Once the effects of other variables are disassociated, infrastructure does not seem to affect the total labor supply significantly. The coefficient of the index of underdevelopment of infrastructure is positive, indicating a larger supply of labor in underdeveloped villages, but the coefficient is not statistically significant.

Infrastructure, however, affects the composition of employment. The estimated supply functions for different types of labor are reported in Table 22. It should be noted that underdevelopment of infrastructure increases the labor supplied to agriculture but reduces the supply of nonagricultural labor. This suggests that nonfarm employment opportunities are less available in the underdeveloped villages; hence rural households tend to supply more labor to agriculture. The estimated coefficients also show that in areas with less-developed infrastructure, households supply more labor to their own account and hire out less than in developed areas. The coefficient of infrastructure in both equations is highly significant statistically.

### Determinants of the Demand for Labor

The survey collected information on the demand for labor only with regard to crop production activity. The following demand function is postulated:

$$\text{DLBR} = f(\text{LNDCR}, \text{HYV}, \text{WRKR}, \text{FEM}, \text{EDCN}, \text{WAGE}, \text{TNC}, \text{INF}),$$

where

DLBR = the number of days of labor used in crop production during 1982, by household,

LNDCR = the amount of land cropped in acres,

HYV = the amount of land allocated to modern varieties of rice in acres, and

TNC = the amount of cropped land rented-in from outside in acres.

The other variables are defined as before.

Estimates of the functions for the use of hired labor and total labor are presented in Table 23. A significant number of farm households in the sample did not hire in labor. In order to avoid problems in estimating parameters when the dependent variable takes a zero value, the parameters of the equation are also estimated using the Tobit method.

## Table 22—Estimates of supply functions for labor by type, all rural households

| Variable | Agriculture | Non-agriculture | Self-Employed | Wage Employment |
|---|---|---|---|---|
| Constant | 148.6<br>(2.69)*** | 44.5<br>(0.73) | −123.5<br>(−2.07)** | 316.5<br>(5.43)*** |
| Number of workers | 117.9<br>(15.0)*** | 83.3<br>(9.68)*** | 113.9<br>(13.44)*** | 87.4<br>(10.56)*** |
| Number of female workers | −66.7<br>(−3.98)*** | −3.6<br>(−0.19) | −0.8<br>(−0.04) | −69.5<br>(−3.93)*** |
| Family size | 10.6<br>(3.97)*** | −2.0<br>(−0.69) | 14.33<br>(4.95)*** | −5.75<br>(−2.04)** |
| Land owned | 4.04<br>(1.46) | −11.63<br>(−3.83)*** | 6.39<br>(2.14)** | −13.98<br>(−4.79)*** |
| Land sown in high-yielding varieties | 13.61<br>(2.62)*** | −26.94<br>(−4.72)*** | 6.52<br>(1.16) | −19.86<br>(−3.62)*** |
| Capital | 1.16<br>(1.88)* | 1.12<br>(1.66)* | 3.99<br>(5.97)*** | −1.70<br>(−2.61)** |
| Education of the household head | −8.91<br>(−4.67)*** | 4.85<br>(2.32)** | −0.39<br>(−0.19) | −3.67<br>(−1.83)* |
| Wage rate | 0.90<br>(0.55) | 6.47<br>(3.58)*** | 4.90<br>(2.76)*** | 2.47<br>(1.42) |
| Consumption level of the village | −6.47<br>(−4.10)*** | −3.18<br>(−1.83)* | −2.53<br>(−1.48) | −7.12<br>(−4.28)*** |
| Underdevelopment of infrastructure | 3.93<br>(1.88)* | −1.85<br>(−0.42) | 10.21<br>(4.51)*** | −8.13<br>(−3.68)*** |
| $\bar{R}^2$ | 0.47 | 0.21 | 0.48 | 0.28 |
| F | 56.7 | 17.9 | 59.9 | 25.6 |

Note: Figures in parentheses are estimated t-values.
*Significant at the 0.10 level.
**Significant at the 0.05 level.
***Significant at the 0.01 level.

The values of the coefficients suggest that the demand for total labor is positively associated with the amount of land cropped, the area allocated to modern varieties, the number of workers in the household, and the level of education of the head of the household. The coefficient of the area under tenancy is also positive, indicating that tenant farmers use more labor than owners. Area under tenancy and the availability of family workers, however, reduce the demand for hired labor. Higher levels of education, on the other hand, increase the demand for hired labor.

The wage rate has a strong negative influence on the demand for labor, supporting the theory that higher wages reduce the demand for labor. The value of the coefficient suggests that increasing the wage rate by Tk 1.00 would reduce the demand for farm labor by nine days. The wage elasticity of demand for labor is estimated at the mean values of the variables at −0.71 for hired labor and −1.04 for total labor. Since the development of infrastructure increases the wage rate by facilitating the mobility of labor, it would have a negative influence on labor use and agricultural production. But as the adoption of new technology advances, upward pressure is generally put on labor demand, which would increase the wage rate if the area is underdeveloped. Development of infrastructure in such cases would encourage migration of labor from outside

**Table 23—Determinants of the use of labor in crop production activity**

| Variable | Demand for Hired Labor |  | Use of Total Labor |
|---|---|---|---|
|  | OLS Estimate | Tobit Estimate | OLS Estimate |
| Constant | 65.2<br>(3.56)*** | 56.2<br>(2.16)** | 214.7<br>(8.70)*** |
| Cropped area | 8.8<br>(10.88)*** | 9.4<br>(32.6)*** | 11.1<br>(10.88)*** |
| Tenanted area | −3.5<br>(−1.28) | −2.9<br>(−1.21) | 14.6<br>(4.19)*** |
| Area under modern varieties | 28.6<br>(13.69)*** | 29.5<br>(17.4)*** | 46.9<br>(17.68)*** |
| Number of family workers | −2.23<br>(−0.65) | −3.10<br>(−0.84) | 17.78<br>(4.08)*** |
| Number of female family workers | −5.13<br>(−0.60) | −8.14<br>(−0.60) | −24.77<br>(−2.26)** |
| Educational level of the head of household | 4.67<br>(5.34)*** | 5.37<br>(4.64)*** | 3.30<br>(2.97)*** |
| Wage rate | −2.97<br>(−3.95)*** | −2.81<br>(−2.62)*** | −9.20<br>(−9.63)*** |
| Index of underdevelopment of infrastructure | −0.51<br>(−0.50) | −0.96<br>(−0.66) | −1.56<br>(−1.22) |
| $\bar{R}^2$ | 0.53 | n.a. | 0.65 |
| F | 65.8 | n.a. | 107.4 |

Notes: Figures in parentheses are estimated t-values. OLS is ordinary least squares. n.a. is not applicable.
**Significant at the 5 percent level.
***Significant at the 1 percent level.

the locality, which would keep the wage rate down and distribute the benefits of the new technology over a wider area.

Once the effects of the other variables are controlled for, infrastructure seems to generate a weak influence on the demand for farm labor. The coefficient of the infrastructure variable is negative, indicating that more labor is used in developed villages, but the coefficient is not statistically significant. This again confirms that the effect of infrastructure is substantial but indirect. The development of infrastructure exerts a positive influence on the demand for labor through its effect on the diffusion of modern technology.

## The Effect of Infrastructure on Employment

To estimate the effect of infrastructure on employment, the labor supply and demand in villages at two ends of the scale of infrastructure development are estimated by evaluating the supply and demand functions at mean values of the variables other than the infrastructure variables. Similarly, three villages at each end of the scale of infrastructure development are selected to represent developed and underdeveloped villages, and the average values of the index of underdevelopment of infrastructure are used in the supply and demand equations. The results are presented in Table 24. As explained earlier, infrastructure has a significant positive effect on the supply of hired labor, but it is offset by a negative effect on the supply of family labor; thus the total effect is

### Table 24—Effect of infrastructure on employment

| Variable | Underdeveloped Villages | Developed Villages | Difference | Statistical Significance |
|---|---|---|---|---|
| | (days worked/year) | | (percent) | |
| Total labor supply | 320 | 301 | −6 | NS |
| Agriculture | 222 | 187 | −16 | WS |
| Nonagriculture | 108 | 124 | 15 | NS |
| Self-employed | 275 | 185 | −33 | S |
| Hired labor | 45 | 116 | 157 | S |
| Demand for farm labor | 163 | 177 | 9 | NS |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.
Notes: NS is not significant; WS is weakly significant; and S is significant.

insignificant. The difference in the use of hired labor at the two ends of the infrastructure scale is about 33 percent.

The supply of nonagricultural labor is about 15 percent higher in developed villages than in underdeveloped villages, but this is achieved by reduction of supply in agriculture. The demand for farm labor is, however, found to be about 9 percent higher in developed than in underdeveloped villages, but the effect is not statistically significant. This opposite effect of infrastructure on the supply and demand for agricultural labor suggests that the labor market is adjusted through either migration of labor or an increase in the wage rate or both. In developed villages, the wage rate is about 12 percent higher than in underdeveloped villages.

## Conclusions

In sum, infrastructure affects the labor market basically by changing the composition of employment. Development of infrastructure generates opportunities for nonfarm employment, where labor is less arduous and productivity may also be higher. Therefore, households that have the necessary capital and skills substitute agricultural labor for nonagricultural, creating more opportunities for wage employment in agriculture for the remaining households. The shift of labor away from agriculture increases the productivity of labor, whereas the shift from self-employment to wage employment increases the duration of employment for the poor, who otherwise would be forced to take up self-employment in nonagricultural activities that are not very productive. The increase in the demand for hired labor in turn puts upward pressure on the wage rate, thus increasing the wage earnings of the poor from the same amount of labor. The development of infrastructure affects employment indirectly through diffusion of labor-intensive modern technology. The changes in the composition of employment induced by infrastructure development lead to an increase in labor productivity and the wage rate, and hence help alleviate poverty.

# 6

# INFRASTRUCTURE, HOUSEHOLD INCOME, AND POVERTY

The impact of infrastructure development on household income largely reflects its effects on production and employment. This chapter measures the contribution of rural infrastructure to family income. The precise meaning of family income is defined, income generation and its distribution is described, and the contribution of infrastructure to household income is estimated quantitatively.

## Definition of Income

Household or family income is defined as the return to family labor and the assets owned after the current cost of production (excluding family labor and rent for owned land and assets) is deducted from the gross value of production, which is estimated using average prices of products for all households in a village. Current cost is the cost incurred by individual households in purchasing inputs, hiring labor (including draft animals, if any), and renting services.

The disaggregation of total family income into a number of components provides a firsthand picture of the effects of infrastructure on various sources of family income. The following scheme is adopted:

1. Income from crop production (CRPI)
    Field crops
    Homestead and garden crops
2. Income from livestock and fisheries (LVFSI)
3. Income from business and industries (BSINDI)
4. Wage income (WGEI)
    Agricultural wage income (AGWI)
    Nonagricultural wage income (NAGWI)
5. Income from miscellaneous sources (MISCI)
6. Total agricultural income (AGI), which comprises
    CRPI + LVFSI + AGWI
7. Total nonagricultural income (NAGI), which comprises
    BSINDI + NAGWI + MISCI
8. Total family income (FINC), which comprises
    AGI + NAGI

## A Descriptive Profile of Household Income

In the profile of household income, the components are described and then the total picture is summarized.

### Income from Crop Production

The average levels of crop income per household, per acre of land, and per capita are shown in Table 25. Average crop income per household is about 10 percent higher in underdeveloped than developed areas. This difference increases to about 16 percent on a per capita basis, clearly reflecting the larger land area and smaller family size in underdeveloped areas. Crop income per acre of owned land, however, is about 20 percent higher in developed than in underdeveloped villages. Income from homestead and garden crops is about 18 percent of crop income. Households generally grow fruits, vegetables, and bamboo in home gardens.

Disaggregating household crop income into landownership groups provides further insights into this source of family income (Tables 26 and 27). The distribution of crop income by the size of land owned shows that functionally landless households (those owning less than 0.5 acres) and small farmers in developed areas obtain a relatively larger share of income from crops than their counterparts in underdeveloped areas. This difference is sharper for small farmers than for any other group. The point is made more explicit by the index of crop income per unit of land in Table 27. In general, the smaller the size of the farm, the larger the income per unit of land. But for all groups the income per unit of land is consistently higher in developed than underdeveloped villages. For the small-farmer group, the difference is about 24 percent. This may reflect differences in the adoption of new technology or crop combinations that are favored by access to markets and possibly to labor input.

### Income from Livestock and Fisheries

Per capita and per household income from livestock and fish production is presented in Table 28. Of the total income originating in this subsector, about 19 percent is

**Table 25—Average annual income from crop production, developed and underdeveloped villages, 1982**

| Source of Income | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | (Tk) | | (percent) |
| Income per household | | | | |
| Field crops | 7,789 | 7,336 | 8,138 | −9.9 |
| Homestead and garden crops | 1,756 | 1,635 | 1,850 | −11.6 |
| Total crop | 9,545 | 8,971 | 9,988 | −10.2 |
| Income per capita | | | | |
| Field crops | 1,229 | 1,115 | 1,321 | −15.6 |
| Homestead and garden crops | 277 | 248 | 300 | −17.3 |
| Total crop | 1,506 | 1,363 | 1,621 | −15.9 |
| Income per acre | | | | |
| Field crops | 3,659 | 4,098 | 3,405 | 20.4 |
| Homestead and garden crops | 825 | 914 | 774 | 18.1 |
| Total crop | 4,484 | 5,012 | 4,179 | 19.9 |
| | | (percent) | | |
| Share of field crop | 81.6 | 81.8 | 81.5 | . . . |
| Share of homestead and garden crop | 18.4 | 18.2 | 18.5 | −1.6 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

## Table 26—Distribution of income from crops, by landownership group, in developed and underdeveloped villages, 1982

| Share of Income | Landless | Small Owner | Medium Owner | Large Owner |
|---|---|---|---|---|
| | | (percent) | | |
| Total households | | | | |
| Developed villages | 31.9 | 36.6 | 23.9 | 7.6 |
| Underdeveloped villages | 29.4 | 31.9 | 27.2 | 11.5 |
| Difference | 8.5 | 14.7 | −12.1 | −33.9 |
| Total crop income | | | | |
| Developed villages | 7.5 | 30.5 | 39.8 | 22.2 |
| Underdeveloped villages | 6.2 | 19.5 | 38.8 | 35.5 |
| Difference | 21.0 | 56.4 | 2.6 | −37.5 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

contributed by poultry, 33 percent by milk, and 48 percent by fish. There is virtually no difference between developed and underdeveloped areas in this production pattern, but there is a large difference in the extent to which each element contributes to family income. On average, households in developed areas derive about 48 percent more income from livestock and fisheries than those in underdeveloped areas. Family income from fish and milk—both perishable products—is 46 percent higher for milk and 57 percent higher for fish in developed than in underdeveloped areas. Income from poultry—a less perishable product because it is usually sold live—is only 31 percent higher in developed than in underdeveloped areas. Easier and quicker access to markets, facilitated by infrastructure development, is a primary cause for such income differences, particularly from livestock and poultry products.

The disaggregated picture is more revealing (see the Appendix, Table 64). Functionally landless households in developed areas derive about 33 percent of their total

## Table 27—Per capita and per acre income from crops by landownership groups in developed and underdeveloped villages, 1982

| Share of Income | Landless | Small Owner | Medium Owner | Large Owner |
|---|---|---|---|---|
| Per capita income (Tk) | | | | |
| Developed villages | 385 | 1,165 | 2,075 | 2,651 |
| Underdeveloped villages | 433 | 1,144 | 1,911 | 3,543 |
| Difference (percent) | −11.0 | 1.8 | 8.6 | −25.2 |
| Index of income per unit of land | | | | |
| Developed villages | 452 | 199 | 142 | 104 |
| Underdeveloped villages | 395 | 161 | 127 | 100 |
| Difference (percent) | 14.4 | 23.6 | 11.8 | 4.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: The landless are those owning less than 0.5 acres. Small owners own 0.5 up to 2.5 acres. Medium owners own 2.5 to 5.0 acres. Large owners own 5.0 acres or more.

## Table 28—Average income from livestock and fisheries, developed and underdeveloped villages, 1982

| Items | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | | | (percent) |
| Income/household (Tk) | | | | |
| Poultry | 276 | 318 | 243 | 30.9 |
| Milk | 488 | 592 | 407 | 45.5 |
| Fish | 693 | 872 | 555 | 57.1 |
| Total | 1,457 | 1,782 | 1,205 | 47.9 |
| Income/capita (Tk) | | | | |
| Poultry | 43.5 | 48.3 | 39.4 | 22.6 |
| Milk | 77.0 | 90.0 | 66.1 | 36.2 |
| Fish | 109.3 | 132.5 | 90.1 | 47.1 |
| Total | 229.8 | 270.8 | 195.6 | 38.5 |
| Share of total income (percent) | | | | |
| Poultry | 18.9 | 17.9 | 20.2 | -11.3 |
| Milk | 33.5 | 33.2 | 33.8 | -1.8 |
| Fish | 47.6 | 48.9 | 46.0 | 6.3 |
| Total | 100.0 | 100.0 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

income from livestock and fisheries, a share that is 74 percent larger than that of their counterparts in underdeveloped villages, who derive 19 percent of their income from these products, although the difference in the proportions of landless households in the total number of households between the two areas is only about 9 percent. The point is made clearer in Appendix Table 65, where the difference in income from livestock and fisheries between developed and underdeveloped areas is shown on a per capita basis. The per capita income of landless households from livestock and fisheries is 109 percent higher in developed than in underdeveloped areas. In fact, it is higher for all groups in developed areas, although the gain of small farmers is comparatively low.

### Income from Business and Industry

The average income derived from business (trade and commerce) and rural cottage industries (items such as handloomed clothes and furniture) is shown in Table 29. Cottage industry as a source of family income is concentrated in specific rural households and villages where certain artisan activities have traditionally been carried out. Therefore, the distribution of income from this source is likely to be skewed. Trade and commerce may also be skewed, but not as much as for cottage industries. Trade and commerce contribute about three-fourths and cottage industries about one-fourth of the total income from business and industry. The average income from this source is about 20 percent higher in developed than in underdeveloped areas. The difference is sharper (about 50 percent) in cottage industries than it is in business (10 percent).

Income from business and industries tends to be more egalitarian in underdeveloped than in developed areas (Appendix Tables 66 and 67). In areas with underdeveloped infrastructure, the unit cost of transport is very high; therefore, trade is conducted on a small scale by the landless and near landless who carry goods on headloads and travel

## Table 29—Average income from business and rural cottage industries, developed and underdeveloped villages, 1982

| Items | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | | | (percent) |
| Income/household (Tk) | | | | |
| Business | 1,388 | 1,464 | 1,330 | 10.1 |
| Industries | 497 | 618 | 404 | 53.0 |
| Total | 1,885 | 2,082 | 1,734 | 20.1 |
| Income/capita (Tk) | | | | |
| Business | 218.9 | 222.5 | 215.9 | 3.1 |
| Industries | 78.4 | 93.9 | 65.6 | 43.1 |
| Total | 297.3 | 316.4 | 291.5 | 12.4 |
| Share of business (percent) | 73.6 | 70.3 | 76.7 | -8.3 |
| Share of industries (percent) | 26.4 | 29.7 | 23.3 | 27.5 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

from one periodic market to another and from village to village. As infrastructure is developed, it is the richer households that reap most of the advantage from the expanded opportunities. Per capita income derived from business and industries is 100-125 percent higher for large and medium landowners in developed than in underdeveloped villages. Although a closer examination than this study affords is needed to determine the precise mechanism that causes this outcome, the following explanation seems logical. Business opportunities in underdeveloped villages are limited to purchasing agricultural products from nearby villages and selling them to other markets and ferrying headloads of consumer goods from village to village. These types of activities can be undertaken with a modest amount of capital by most households. In contrast, opportunities for trade and commerce are more abundant in developed villages, and large-scale operations pay better than headload businesses. This makes the role of capital more important, and only the richer households with better access to capital can undertake the larger activities.

### Wage Income

Household income derived from selling labor services to agricultural and nonagricultural employers is included in this category (Table 30). Of the total wage income, about two-thirds originates in nonagricultural activities and one-third in agricultural activities. The average wage income of households in the developed villages is twice that in the underdeveloped villages. Wage income from nonagricultural sources is about 123 percent larger in the developed than in the underdeveloped areas. Because of larger family size, per capita wage income is only 88 percent higher in the developed than in the underdeveloped villages.

The disaggregated picture (Appendix Tables 68 and 69) reveals that the small and medium landowners derive a relatively larger share of the increased wage income associated with infrastructure development. While the per capita wage income of landless households in developed areas is only 36 percent higher than that of their counterparts in underdeveloped villages, per capita wage income of small and medium landowners in developed villages is 95 to 165 percent higher. This may be because

## Table 30—Average wage income, 1982

| Item | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | | | (percent) |
| Income/household (Tk) | | | | |
| Wages from agriculture | 968 | 1,249 | 751 | 66.3 |
| Wages from nonagriculture | 1,845 | 2,675 | 1,202 | 122.5 |
| Total | 2,813 | 3,924 | 1,953 | 100.9 |
| Income/capita (Tk) | | | | |
| Wages from agriculture | 152.7 | 189.8 | 121.9 | 55.7 |
| Wages from nonagriculture | 291.0 | 406.5 | 195.1 | 108.3 |
| Total | 443.7 | 596.3 | 317.0 | 88.1 |
| Share of agricultural wages (percent) | 34.4 | 31.8 | 38.4 | −17.2 |
| Share of nonagricultural wages (percent) | 65.6 | 68.2 | 61.6 | 10.7 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

some nonagricultural work requires skills that landless laborers may not be able to acquire as easily as workers in better-off small and medium landowning households. In fact, further analysis of the data indicates that the small and medium landowning households increase their wage income proportionately more than all other households from nonfarm wage employment. The average wage rate (wage income divided by employment) in these categories is almost two times the wage rate in the landless category. This is due to a higher proportion of nonfarm salaried employment, at a daily wage higher than that of casual workers, in small and medium landowning households. Access to salaried jobs appears to be limited for the landless.

### Income from Miscellaneous Services

Income from miscellaneous services includes remittances by household members who work in personal services and petty jobs, sometimes away from home, perhaps even in a foreign country. Another source is income from charity, including government relief donations and private help to the poor on religious or personal grounds. As Table 31 and Appendix Table 70 show, the amount of miscellaneous income is not small; the average income per household on this account is Tk 3,844. Such income is found to be slightly larger on both a household and per capita basis in underdeveloped areas. Miscellaneous income generally is distributed fairly evenly across all households, although richer households have a slightly larger share, mainly because remittances contribute a larger share in such households.

### Summary of Total Family Income

The average family income in 1982 for the entire sample is estimated to be Tk 19,544, which is equivalent to a per capita annual income of about US$110 at the official exchange rate (Table 32). About 61 percent of the income is derived from agricultural sources.

Total family income is only 8 percent higher in the developed area than in the underdeveloped. But the contribution of the various components of total income differ rather drastically. Crop income per family is about 10 percent higher in underdeveloped villages because, as mentioned earlier, land area per household is higher there.

### Table 31—Average income from miscellaneous services in developed and underdeveloped villages, 1982

| Item | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | (Tk) | | (percent) |
| Income per household | 3,844 | 3,625 | 4,013 | −9.7 |
| Income per capita | 606.3 | 550.9 | 651.5 | −15.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

Incomes from livestock and fisheries, business and industries, and wages are 20-100 percent higher in developed villages, but miscellaneous income is higher in underdeveloped villages. The differences in farm size and miscellaneous income serve to cancel out much of the effect of increased income from other sources, so that the difference in total family income between developed and underdeveloped areas is reduced to only 8 percent.

Households benefit differently from infrastructure development depending on the size of their landholdings. Per capita income of large landowners is 2.5 times higher

### Table 32—Summary of total household income, developed and underdeveloped villages, 1982

| Source of Income | All Households | Developed Villages | Underdeveloped Villages | Difference[a] |
|---|---|---|---|---|
| | | (Tk) | | (percent) |
| Crops | 9,545 | 8,971 | 9,988 | −10.2 |
| Share in total | (48.8) | (44.0) | (52.9) | . . . |
| Livestock and fisheries | 1,457 | 1,782 | 1,205 | 47.9 |
| Share in total | (7.5) | (8.7) | (6.4) | . . . |
| Business and industries | 1,885 | 2,082 | 1,734 | 20.1 |
| Share in total | (9.6) | (10.2) | (9.2) | . . . |
| Wages | 2,813 | 3,924 | 1,953 | 100.9 |
| Share in total | (14.4) | (19.3) | (10.3) | . . . |
| Wages from agriculture | 968 | 1,249 | 751 | 66.3 |
| Wages from nonagriculture | 1,845 | 2,675 | 1,202 | 122.5 |
| Miscellaneous | 3,844 | 3,625 | 4,013 | −9.7 |
| Share in total | (19.7) | (17.8) | (21.2) | . . . |
| Total agricultural income | 11,969 | 12,000 | 11,945 | 0.46 |
| Share in total | (61.2) | (58.9) | (63.2) | . . . |
| Total nonagricultural income | 7,575 | 8,384 | 6,948 | 20.7 |
| Share in total | (38.8) | (41.1) | (36.8) | . . . |
| Total household income | 19,544 | 20,384 | 18,893 | 7.9 |
| Share in total | (100) | (100) | (100) | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: Numbers in parentheses are percentages.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

than that of landless households in underdeveloped villages. This gap is smaller in developed villages (Table 33). Landless households gain proportionately more from infrastructure development through income from livestock and fisheries and wages. Similarly, small landowners gain from wages (largely nonagricultural) and livestock and fisheries. Medium landowners enhance their per capita income by seizing most of the opportunities afforded by infrastructure. The benefits derived from infrastructure by large landowners are mostly gained through business and trade. The sum of all these effects results in a higher per capita income of 14.5 percent for the landless, of 4.7 percent for small owners, and of 15.4 percent for medium owners in developed villages, even though families are larger and farm sizes smaller in developed villages.

## Disposable Income

Disposable income is the income available after direct taxes are paid (see the Appendix, Table 71). Rural households pay only a small amount of taxes, mainly on land and to local administrative institutions such as union councils. Payment of agricultural income taxes is almost nil.

The average effective tax rate for the entire sample is only 0.23 percent of gross family income. The effective tax rate in underdeveloped areas is 0.18 percent and that in developed areas 0.29 percent. Therefore, the effective tax rate for households in developed villages is 61 percent higher than that in underdeveloped villages. The

## Table 33—Summary of per capita income, by landownership group, developed and underdeveloped areas, 1982

| Source of Income | Landless | Small Owner | Medium Owner | Large Owner |
|---|---|---|---|---|
| | | (Tk) | | |
| Crops | | | | |
| Developed | 385 | 1,165 | 2,075 | 2,651 |
| Underdeveloped | 433 | 1,144 | 1,911 | 3,543 |
| Difference | (-11.0) | (1.8) | (8.6) | (-25.2) |
| Livestock and fisheries | | | | |
| Developed | 335 | 193 | 242 | 433 |
| Underdeveloped | 160 | 162 | 192 | 312 |
| Difference | (109.0) | (19.0) | (26.1) | (38.9) |
| Business and industries | | | | |
| Developed | 261 | 180 | 306 | 903 |
| Underdeveloped | 286 | 360 | 137 | 434 |
| Difference | (-9.0) | (-50.1) | (123.7) | (108.0) |
| Wages | | | | |
| Developed | 945 | 690 | 345 | 67 |
| Underdeveloped | 693 | 354 | 130 | 95 |
| Difference | (36.3) | (95.0) | (164.9) | (-29.5) |
| Miscellaneous | | | | |
| Developed | 436 | 518 | 616 | 778 |
| Underdeveloped | 489 | 602 | 736 | [illegible] |
| Difference | (-10.8) | (-14.0) | (-16.3) | (-2.1) |
| Total family income | | | | |
| Developed | 2,362 | 2,746 | 3,584 | 4,832 |
| Underdeveloped | 2,061 | 2,622 | 3,106 | 5,179 |
| Difference | (14.5) | (4.7) | (15.4) | (-6.7) |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.
Note: Numbers in parentheses are percentages.

difference would be even greater if landholdings were not larger—and thus liable for more land taxes—in underdeveloped villages. Since the legal tax rate applicable to households is generally the same for all villages, it can be assumed that infrastructural facilities contribute positively to the efficiency of tax collection, as reflected by the larger share of income that goes to taxes in developed areas.

## Net Effect of Infrastructure Development

In measuring the effects of infrastructure development on household income, it should be kept in mind that household income is only a part, but a significant part, of the total effect. Any effect that spills over to other areas and households is, therefore, not covered by this approach. Such spillovers occur when a firm or government brings capital to a center of infrastructure development from outside the area and takes back profit to the original place of residence. Moreover, the methodology used to compare villages with different degrees of infrastructure development cannot take account of the effect that is transferred from developed area to underdeveloped area through factor mobility. For example, a household with a large amount of capital may be able to take its capital to a center of infrastructure development and return the income earned to its underdeveloped village. Such income will be counted as part of the income of households in underdeveloped villages, even though the earning opportunity was made possible by infrastructure development. For this reason, the estimate of the productive impact of infrastructure development is probably more accurate for crop production, livestock and fisheries, and wage income than for income earned through liquid capital assets like business. Land, family labor, and to a degree, wage labor, are less mobile than liquid capital.

Some indications of the direction and magnitude of the effects of infrastructure development, based on a comparison of averages of the two classifications of villages, have already been presented earlier in this section. However, comparing averages does not adequately capture the pure effect of infrastructure or take account of differences in factors unrelated to infrastructure. This is attempted below.

### Crop Income

In Chapter 5, it was shown that bridging the infrastructural gap between the three least and the three most infrastructurally developed villages would increase crop production by at least 30 percent, which is the pure effect of infrastructure on crop production. Given this basic measurement, estimating the effect of infrastructure on income from crop production is straightforward based on the following relation:

$$\text{CRPI} = \text{GVPAG} - \text{CST} = \alpha\text{GVPAG},$$

where

CRPI = income from crop production,
GVPAG = gross value of crop production,
CST = current cost of production, and

$$\alpha = \left(1 - \frac{\text{CST}}{\text{GVPAG}}\right).$$

The results are as follows:

$$AGINC_d = 0.68\,GVPAG_d \text{ for the three most developed villages, and}$$

$$AGINC_u = 0.74\,GVPAG_u \text{ for the three least developed villages.}$$

On the basis of these relations, it is estimated that an increase in agricultural *production* of 32 percent, measured as the pure effect of infrastructure development in the context of the sample villages, results in an increase in *income* from crop production of 24 percent of base income.

**Wage Income**

The pure effect of infrastructure development on wage income (that is, income from hiring out labor services) can theoretically be estimated on the basis of the simple methodology shown in Figure 2. In the diagram, the wage rate ($W_u$) and employment ($E_u$) represent the situation of the three least developed villages, where wage income is $W_u \times E_u$. When development of infrastructure reaches the level of the three most developed villages, the wage rate is equivalent to $W_d$ and employment to $E_d$. The wage income under this improved situation is $W_d \times E_d$. The wage income that can be attributed to infrastructure development is equal to $(W_d \times E_d) - (W_u \times E_u)$.

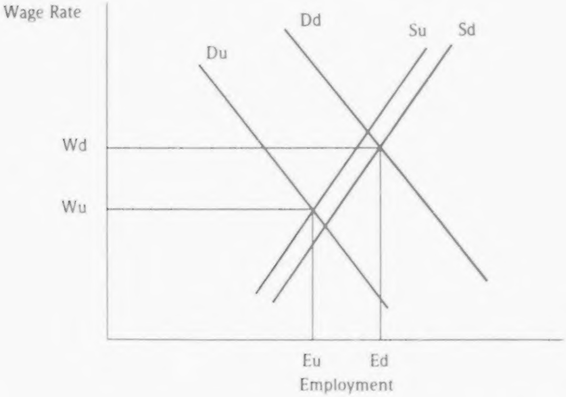
To use this model, estimates of supply and demand shifts attributed to infrastructure are necessary, as well as their elasticities. Supply parameters for hired labor were estimated in Chapter 5, but all demand parameters could not be estimated. An alternative approach—a regression model of the recursive type—is therefore adopted.

The first-stage equation is

$$WGEI = f(WRKR, EDCN, INF, WGRT, CPTL, FEM, HYV, FSZ, LAND). \qquad (20)$$

The second-stage equations are

Figure 2—Determination of wage income



$$\mathrm{FEM} = f(\mathrm{INF}, \mathrm{FSZ}), \tag{21}$$

$$\mathrm{WRKR} = f(\mathrm{INF}, \mathrm{FSZ}, \mathrm{LAND}), \tag{22}$$

$$\mathrm{LAND} = f(\mathrm{INF}, \mathrm{FSZ}), \tag{23}$$

$$\mathrm{HYV} = f(\mathrm{INF}, \mathrm{IRGN}, \mathrm{LAND}, \mathrm{CPTL}, \mathrm{CRDTI}, \mathrm{CRDTNI}), \tag{24}$$

$$\mathrm{CPTL} = f(\mathrm{LAND}, \mathrm{INF}), \tag{25}$$

$$\mathrm{EDCN} = f(\mathrm{INF}, \mathrm{LAND}), \text{ and} \tag{26}$$

$$\mathrm{WGRT} = f(\mathrm{EDCN}, \mathrm{INF}, \mathrm{HYV}). \tag{27}$$

The symbols are defined:

WGEI = wage income in taka per household,
WRKR = number of workers in the family,
EDCN = level of education of the head of the household,
INF = index of infrastructure underdevelopment,
WGRT = wage rate in taka per day,
CPTL = total value of capital stock in taka (excluding land),
FEM = number of female laborers in the household,
FSZ = family size,
HYV = land area under high-yielding varieties,
LAND = area of owned land,
IRGN = irrigated land area,
CRDTI = credit from institutional sources, in 1,000 taka, and
CRDTNI = credit from noninstitutional sources, in 1,000 taka.

All of the variables for the analysis of income attributable to infrastructural factors are measured at the household level, except infrastructure, which is a village-level variable. Thus, every household in a village has the same index of infrastructure underdevelopment; regression equations are estimated using all households and villages.

Equation (20) includes most of the variables that affect the supply of and demand for wage labor, and it captures the effects of these variables on household wage income. The effect of infrastructure in this equation represents the direct access effect. The indirect effect via these other variables is measured through the second-stage equations. Equations (21) through (27) measure the relations between infrastructure and the other variables, that is, the explanatory variables of equation (20). Their estimates, which use the average infrastructural index of the three most developed and the three least developed villages, provide the estimated values of explanatory factors for the two groups of villages. The estimated values of the variables are plugged into the estimated equation (20) to measure the wage income in the two groups of villages. Estimates of all of these equations are given in the Appendix, Table 72. Only the coefficients where infrastructure proved to be a significant factor in equations 21 through 27 are used to derive the wage incomes of developed and underdeveloped villages.

Estimates based on the above procedure show that the average income in the three most developed villages is 92 percent larger than the wage income per household in the three least developed villages. A substantial part of this difference in wage income can be attributed to the larger proportion of high-wage salaried employment in developed areas compared with underdeveloped. This has resulted in a larger difference in wage income than in employment (Chapter 5). Most of this difference is the result of infrastructure development.

## Income from Livestock and Fisheries

As in the case of wage income, the net effect of infrastructure on income from livestock and fishery activities is estimated through a recursive regression model. The first-stage equation is

$$\text{LIVFSI} = f(\text{EDCN, NWCH, WRKR, INF, PLBA, CPTLA, FEM, LAND, ANML}). \quad (28)$$

The second-stage equations are

$$\begin{aligned}
\text{EDCN} &= f(\text{INF, LAND}), && (29)\\
\text{NWCH} &= f(\text{INF, WRKR, LAND, FSZ}), && (30)\\
\text{WRKR} &= f(\text{INF, FSZ, LAND}), && (31)\\
\text{PLBA} &= f(\text{INF, WRKR, LAND, FSZ}), && (32)\\
\text{CPTLA} &= f(\text{INF, WRKR, LAND}), && (33)\\
\text{FEM} &= f(\text{INF, FSZ}), && (34)\\
\text{LAND} &= f(\text{INF, FSZ}), \text{ and} && (35)\\
\text{ANML} &= f(\text{INF, WRKR, FSZ, LAND}), && (36)
\end{aligned}$$

where the new variables are defined:

LIVFSI = income per household from livestock and fisheries,
NWCH = number of family members below the age of 16 (child),
CPTLA = agricultural capital in taka (excluding land),
PLBA = number of persons engaged in permanent hired labor (adult), and
ANML = number of draft animals.

The equations are estimated in the Appendix, Table 73.

The hypotheses that underlie the specifications are founded on the field knowledge and general experience of the authors in the rural economy of Bangladesh. There are few previous studies to supplement the hypothetical basis.

In general, labor input is a basic requirement for raising milch cows, poultry, and fish. Child labor is frequently used for feeding cows and pasturing cattle. All of the in-house work of milking, cleaning cowsheds, and feeding poultry is done by women. Housing and feeding poultry and guarding them against predators are tasks done by women and children. Maintaining fisheries, on the other hand, is mainly the job of adult male workers, including hired labor, if any. Landowners have an advantage over the landless in livestock and fishery activities. Owning some amount of land is helpful in raising livestock, which are generally fed crop by-products in Bangladesh. To have a fishing pond, it is necessary to own land. Fishing in public bodies of water, however, mainly depends on the labor force of a family. But commercial fishing in rural areas is usually a caste-specific activity. Generally the amount of draft power a household commands is determined by the number of working bullocks and cows. Using cows as draft animals increases the amount of draft power available, but it decreases the amount of milk and hence some of the income from milk production.

The dominant factor determining a household's income from livestock and fisheries is its access to market. How quickly and frequently a household can take its products to market determines the size of its income from livestock and fisheries. Milk from cows milked in the morning must be sold by noon. The case is similar for fish. If livestock products and fish are not easily marketed, households have little incentive to increase their output, since production is only for home consumption.

The net effect of infrastructure development is obtained by following the same procedure as for wage income. This estimate shows that income from livestock and fisheries in the three most developed villages is about 78 percent higher than that in the three least developed villages. This increment is the pure effect of infrastructure development.

### Income from Business and Industries

The following model is estimated to measure the infrastructural effect on household income from business and industries. The first-stage equation is

$$\text{BSINDI} = f(\text{CRDNI}, \text{CRDI}, \text{LAND}, \text{INF}, \text{EDCN}, \text{WRKR}, \text{CPTLB}). \tag{37}$$

The second-stage equations are

$$\begin{aligned}
\text{CPTLB} &= f(\text{CRDI}, \text{WRKR}, \text{INF}, \text{EDCN}, \text{CRDNI}, \text{LAND}), &(38)\\
\text{WRKR} &= f(\text{INF}, \text{FSZ}, \text{LAND}), &(39)\\
\text{EDCN} &= f(\text{INF}, \text{LAND}), &(40)\\
\text{LAND} &= f(\text{INF}, \text{FSZ}), &(41)\\
\text{CRDI} &= f(\text{INF}, \text{LAND}, \text{EDCN}, \text{HYV}), \text{ and} &(42)\\
\text{CRDNI} &= f(\text{INF}, \text{LAND}, \text{EDCN}, \text{HYV}), &(43)
\end{aligned}$$

where the new variables are defined:

BSINDI = household income from business and industries, and

CPTLB = working capital for business and industries.

The equations are estimated in the Appendix, Table 74.

Following the same procedure as before—solving for the average income of the three most and the three least developed villages, the difference in income attributable to infrastructure is not found to be large. The income from business and industries in developed villages is only 17 percent higher than that in the underdeveloped group. This effect is primarily the indirect contribution of infrastructure through education and noninstitutional credit. It seems that business capital and institutional credit are the two most important factors behind income from business and industries. The direction of relations between these two factors and infrastructure is as expected, but their coefficients are only weakly significant.

Capital for business and industries is the central force in generating income from these sources. Institutional credit, mainly supplied through the public system, reinforces business and industrial capital. Since such credit is mostly based on ownership of land, it is the large landowners who derive most of the gains in capital from business and industries. Because it is easier to move capital than other resources, even large landowners located in remote areas may overcome infrastructural backwardness by availing themselves of investment opportunities in developed areas.

Clearly, if opportunities in business and rural industries that result from infrastructure development are to be accessible to all households, credit policies similar to those of the Grameen Bank will play critical roles (Hossain 1988a). How this type of credit can be expanded to larger areas, along with infrastructure development, is a subject that, though not covered here, deserves serious consideration.

### Summary of Infrastructural Effects

In summarizing the impact of infrastructure on income from various sources, the income from miscellaneous sources is not taken into consideration because of difficulties in conducting similar analysis. It is assumed that this source of income does not make any difference, although it seems likely that income from sources listed under miscellaneous will be larger in developed than in underdeveloped areas.

Table 34 indicates that the difference in infrastructural endowment of the two sets of villages causes a difference of about 33 percent in income between the two groups of villages.

## Conclusions

The analysis of income from crop production, livestock and fisheries, wages, and business and industries indicates that infrastructure development contributes tremendously to increased household income. Income from crop production increases by about 24 percent, and income from livestock and fisheries increases by about 78 percent due to infrastructure development. Wage income almost doubles. What is even more significant is the change in the distribution of income arising from infrastructure development. Income from crops, wages, and livestock and fisheries increases proportionately more for the landless and small farmers than for large landowners. In the case of income from business and industries, the pure effect of infrastructure is relatively small; an

**Table 34—Summary of the effects of infrastructure development on income**

| Source of Income | Weight[a] | Increase in Income[b] | Weighted Average Increase |
|---|---|---|---|
| | | (percent) | |
| Crop | 0.49 | 24.00 | 11.76 |
| Livestock and fisheries | 0.08 | 78.00 | 6.24 |
| Wage | 0.14 | 92.00 | 12.88 |
| Business and industries | 0.10 | 17.00 | 1.70 |
| Miscellaneous | 0.19 | 0.00 | 0.00 |
| Total | 1.00 | . . . | 32.58 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Weights are shares of total family income for all households.

[b] These increases were calculated as shown in previous sections and reflect the difference between the three most underdeveloped villages and the three most developed villages.

increase in household income of only 17 percent can be attributed to infrastructure development. Moreover, income from this source is largely garnered by richer households due to their greater access to capital. Along with infrastructure development, access to capital for poorer households through institutions of the Grameen Bank type is a critical requirement if the fruits of development are to be evenly distributed. It is likely that part of the income generated by infrastructure spills over from households to organized sectors so that a measurement based entirely on household income may fail to capture the full impact of infrastructure, particularly of income from business and industries.

The implication that development of rural infrastructure helps alleviate poverty in Bangladesh is, by far, the most important result of this research. The conventional view that development of rural infrastructure is likely to aggravate poverty is found to be baseless. To the contrary, the results indicate infrastructure development has a substantial effect on rural poverty by increasing agricultural and wage income in landless and small landowning households. The conventional view suffers from an inability to see the linkage effects of rural infrastructure that indirectly influence income-generating activities for the poor.

# 7

# LINKAGE BETWEEN INFRASTRUCTURE AND CONSUMPTION

About 14 percent of household income in rural Bangladesh is saved and the remaining 86 percent is spent on consumption goods. The demand for consumer goods, therefore, is a powerful source of economic growth. Rural infrastructure's role in augmenting agricultural and nonagricultural production and income, particularly income from wages, livestock, and trade and services, as highlighted in the previous chapter, is realized through a complex set of interrelations. First, through its effect on agricultural production, infrastructure enhances agricultural income, which in turn creates additional demand for various consumer goods. Then production and marketing of these consumer goods generate additional income and employment opportunities in nonagricultural sectors. Second, infrastructure development facilitates production and marketing of these nonagricultural goods by cutting costs. Third, infrastructure may directly influence the taste patterns of consumers and therefore may result in different marginal propensities of expenditure in developed and underdeveloped areas. Infrastructure development changes taste patterns by making information about and demonstrations of products more accessible. These effects on consumption parameters and taste patterns, when multiplied throughout the economy, could lead to broad differences arising from any initial increase in income.

This multiplier effect, via the interindustry linkages, has been studied by different researchers in different contexts. Bell, Hazell, and Slade (1982) conclude from a study of the Muda irrigation project in Malaysia that for each dollar of agricultural income created directly by the project investment, an additional 80 cents of value added was created indirectly in the local nonfarm sectors. The source of two-thirds of this additional 80 cents was traced to consumer goods and services. In a study of the interrelationship between agricultural and industrial growth performance in India, Rangarajan (1982) shows that a 1.0 percent addition to the agricultural growth rate induced a 0.5 percent incremental growth of industrial output and a 0.7 percent additional growth of national income. Recognizing the importance of these induced growth linkages, Mellor (1976) argues that contrary to conventional wisdom, agriculture can play the role of the leading sector in the process of development.

The conventional wisdom, which says that development must come through industrialization, originated from or at least was reinforced by studies that showed agriculture to have much smaller linkage effects than industry (Chenery and Watanabe 1958). These initial studies of interindustry production, employment, and income linkages generally failed to adequately capture the indirect effects, particularly the effects on the second, third, and subsequent rounds of consumption expenditure.

In order to indicate more objectively the significance of consumption expenditures in the multiplier effect of an economy, it is perhaps necessary to define linkage effects and then present some empirical evidence. Three linkage effects have been examined in the literature: (1) production linkage (the interindustry linkage most often measured), (2) employment linkage, and (3) income generation linkage (Yotopoulos and Nugent 1976). These linkage effects are defined, respectively, as the increases in production, employment, and income resulting from a one-unit increase in the final demand.

Measurement of the production linkage has sometimes been limited to direct backward and forward linkages without taking into account indirect second and third round effects. In the literature, a concept of the total production linkage is developed that takes into account indirect second and third round production effects. The employment linkage is derived from the wage component in total production, that is, the employment coefficient. Estimation of both the production and employment linkages ignores income, which is exogenously given. No relation between final demand and income is developed and incorporated, an obviously rigid assumption. Given the households' marginal propensities to consume different commodities, the structure of final demand is also affected. The household demand thus induced further stimulates a sector's demand for intermediate products and for labor, again with indirect effects on household income. This process describes the income generation linkage effect.

A study of the Taiwanese economy by Lin (1973) illustrates the measurement of these three linkage effects (Table 35). It gives the linkage indexes and their rankings for a number of broad sectors. The results of the study are revealing though somewhat deficient in capturing the total effects of linkage because the static input-output framework used in the study is not effective enough to fully account for the interrelations of consumption, income, and production. The results nevertheless reflect a radical change in the ranking of the linkage effects by sector, depending on whether the major concern is with production, employment, or income linkages. Agriculture ranks low in production linkages but highest in employment and income linkages. One important factor that contributes to the high income linkage is the marginal propensity to consume.

The linkage coefficients described above are expressed per unit of final demand. The absolute magnitude of the linkage effects will not only depend on these coefficients but also on the level of demand that emanates from each sector. The absolute linkage

**Table 35—Total interindustry linkage indices and their rankings, Taiwan, 1966**

| | Total Production Linkage | | Employment Linkage | | Income Generation Linkage[a] | |
|---|---|---|---|---|---|---|
| Industry | Index | Rank | Index | Rank | Index | Rank |
| Agricultural production for food | 1.897 | 7 | 0.852 | 3 | 1.637 | 3 |
| Agricultural production for raw materials | 1.497 | 10 | 0.908 | 1 | 1.804 | 1 |
| Working capital for agriculture | 2.455 | 3 | 0.725 | 10 | 1.140 | 8 |
| Food processing | 2.158 | 6 | 0.673 | 12 | 1.089 | 11 |
| Mining | 1.580 | 11 | 0.863 | 2 | 1.673 | 2 |
| Textiles and rubbers | 2.623 | 2 | 0.819 | 6 | 1.100 | 10 |
| Nonmetal products | 2.172 | 5 | 0.764 | 9 | 1.110 | 9 |
| Metal products | 2.793 | 1 | 0.825 | 5 | 1.067 | 12 |
| Utilities | 1.883 | 8 | 0.713 | 11 | 1.355 | 6 |
| Construction | 2.417 | 4 | 0.839 | 4 | 1.416 | 5 |
| Transport and communication | 1.858 | 9 | 0.787 | 7 | 1.329 | 7 |
| Other services | 1.286 | 12 | 0.768 | 8 | 1.517 | 4 |

Source: W. L. Lin, "Economic Interactions in Taiwan: A Study of Sectoral Flows and Linkages" (Ph.D. dissertation, Stanford University, 1973).

[a] Income from rent and capital is assumed to be small for households and therefore is ignored.

effect for the agricultural sector may be more important than the linkage effect per unit of final demand in most developing countries because the share of agricultural products in final demand is generally the largest. Therefore, the analysis of both average and marginal budget shares is relevant to this study.

Because consumption expenditure is critically important in multiplying the economic activities in a system, this chapter devoted to the analysis of consumption expenditures emphasizes demand parameters and consumption patterns in infrastructurally developed and underdeveloped areas. An attempt is made to determine the effects of infrastructure development on indirect nonfarm activities induced by consumption expenditures. No attempt is made, however, to measure the multiplier effect since that would require a general equilibrium framework.

## Consumption Pattern and Demand Parameters

Expenditures on food items, as well as some services, are based on an aggregation of weekly data. Purchases of an irregular nature (such as clothes, education, and health) and major expenditures are based on an aggregation of quarterly data to annual levels. The model is therefore a set of Engel functions relating annual expenditures on different goods and services to a measure of total income and household characteristics. It is estimated using cross-section data.

Although household income data are available from the survey, total annual consumption expenditure is used as a proxy for income. There are two reasons for this. First, consumption expenditure is usually a better indicator of permanent income, which is considered to be a more important determinant of consumption behavior (Friedman 1952). Second, the estimates of household income are often not quite reliable: although there is not much difference between the average income and total expenditure (including investment expenditure), the variability of the latter is much larger than the former. Therefore, total expenditure seems to be a more reasonable variable than estimated income for measuring the behavioral pattern of income-consumption relations.

### Choice of Functional Form

A flexible functional form is desirable for estimating consumption parameters. For one thing, the chosen function must provide a good statistical fit for a wide range of commodities. A nonlinear function as developed by Hazell and Röell (1983), following the Working-Leser model, is adopted in this study:

$$S_i = \beta_i + \alpha_i/E + \tau_i \log E, \qquad (44)$$

where

$S_i = E_i/E$;

$E_i$ = the expenditure on the *i*th good;

$E$ = total expenditure; and

$\beta_i$, $\alpha_i$, and $\tau_i$ are constants.

Equation (44) is equivalent to the Engel function:

$$E_i = \alpha_i + \beta_i E + \tau_i E \log E. \qquad (45)$$

In comparing the expenditure behavior of households with different incomes, allowance must be made for some household characteristics and infrastructural factors. Since infrastructure is a primary concern of this study, the functional form must accommodate this concern. Therefore, a number of household characteristics (family size, farm size, and so forth) and the infrastructural index are included in the Engel functions, and this has been done in a way that allows both the intercept and the slope of the Engel functions to be shifted. Let $Z_j$ denote the *j*th household characteristic or infrastructural index (note that for this variable, all households in a village have the same index numbers and only villages differ), and let $\mu_{ij}$ and $\gamma_{ij}$ be constants. The complete model is then

$$E_i = \alpha_i + \beta_i E + \tau_i E \log E + \sum_j (\mu_{ij} Z_j + E \gamma_{ij} Z_j). \tag{46}$$

In the expenditure share form, equation (46) is equivalent to

$$S_i = \beta_i + \alpha_i / E + \tau_i \log E + \sum_j (\mu_{ij} Z_j / E + \gamma_{ij} Z_j). \tag{47}$$

Given the chosen Engel function, the marginal and average budget shares for the *i*th good ($MBS_i$ and $ABS_i$, respectively) and the expenditure elasticity ($e_i$) can be derived as follows:

$$MBS_i = dE_i/dE = B_i + \tau_i (1 + \log E) + \sum_j \gamma_{ij} Z_j. \tag{48}$$

$$ABS_i = S_i = \text{equation (47), and} \tag{49}$$

$$e_i = MBS_i / ABS_i. \tag{50}$$

Expenditures are given in per capita terms. This enables ready comparison between household groups (between developed and underdeveloped areas, villages, or income classes, for example). But since family size is also included as one of the Z variables, family size can influence both the intercept and the slope of the Engel function for an individual commodity.

### Estimation of the Model

The model can be estimated using either equation (46) or (47). Equation (47) is chosen because normalizing $E_i$ by dividing it by E removes an otherwise troublesome problem of heteroskedasticity—a problem that is inherent in cross-section data. A disadvantage of estimating the share equation is that the adjusted $R^2$ coefficients are typically smaller (Prais and Houthakker 1971).

In estimating the model, it is not necessary to impose any restriction to ensure that $\sum_i \beta i = 1$ and $\sum_i \alpha_i = \sum_i \mu ij = \sum_i \gamma iJ = \sum_i \tau ij = 0$ in equation (46). Because of the way the model is specified, these conditions are automatically fulfilled. Specifically, provided that each budget share equation has an intercept on the right-hand side and that each equation contains all the same variables and is estimated by least-squares regression, adding up is assured, as shown by Prais and Houthakker (1971). This result is affected neither by the inclusion of additional nonlinear terms in E, nor by the inclusion of Z variables. Ordinary least squares (OLS) was therefore retained as the estimating procedure.

### Detailed Commodity Results by Infrastructural Groups

For consumption behavior in rural households, the marginal budget shares in developed and underdeveloped groups are computed by taking into account the infrastructural index numbers and their coefficients in the regression equation (see the Appendix, Table 75). The average index of the three most developed villages is taken and that of the three least developed villages. The level of significance of the infrastructural index in the regression equation is shown in the Appendix, Table 76. When interpreting average consumption behavior and comparing it between developed and underdeveloped villages, it is critical that the income effect is not confused with the infrastructural effect. Therefore, the budget shares and expenditure elasticities are calculated at a constant level of average per capita total expenditure (Tk 2,706) for both groups. The average per capita expenditures in the two groups, however, differ by only 1.2 percent.

*Cereals.* Both average and marginal budget shares are substantially higher in the underdeveloped areas. Obviously, infrastructure development reduces the propensity to consume cereals. The expenditure elasticity is about 23 percent higher in underdeveloped villages. This is a phenomenon analogous to the difference in consumption patterns in urban and rural households. The marginal budget share and the expenditure elasticity are negative for wheat in both developed and underdeveloped areas.

*Noncereal field crops, except sugar and oilseeds.* There is little difference in consumption behavior between the two groups for these commodities. The average budget share is 9.5 percent in developed areas and 9.2 percent in underdeveloped, and the expenditure elasticity of the group as a whole differs only slightly (0.82 in developed, 0.91 in underdeveloped).

*Narcotics.* This group represents products such as tobacco in various forms, betel leaf, areca nuts, and so forth. Both the average and marginal propensities to consume narcotics are substantially larger in developed villages. The average share is 70 percent larger and the marginal share 125 percent larger in developed villages. This also results in a larger expenditure elasticity for narcotics in developed villages.

*Sugar and Oils.* The average budget share for these products is about 13 percent larger and the marginal budget share is about 33 percent larger in developed than in underdeveloped villages. The expenditure elasticity of sugar products in developed areas is about 28 percent larger, while the expenditure elasticities of oils are similar.

*Tea.* Tea as a beverage takes 1.1 percent of total expenditure in the developed group, but its consumption is almost zero in the underdeveloped group. Roadside tea stalls are a visible sign of trade in developed areas.

*Fruits.* The average budget share for fruits is higher in underdeveloped areas, but the marginal budget share is larger in developed areas, resulting in higher expenditure elasticity in developed areas.

*Fish and Livestock Products.* The average budget share of fish and livestock products, including milk and milk products, is about 61 percent larger in developed groups, and the marginal budget share is about 53 percent larger in developed groups. This has resulted in an overall expenditure elasticity of 1.7 in developed and 1.8 in underdeveloped groups.

*Fuel and Energy.* The overall propensity to spend on fuel does not differ greatly between the developed and underdeveloped areas, but there are considerable differences between the two in the pattern of substitution among various sources of energy. The negative expenditure elasticity for cow dung as a fuel in developed areas and the positive income elasticity in the underdeveloped areas could have far-reaching implications for sustaining soil fertility. As infrastructure becomes more developed, cow dung will be used as fertilizer instead of fuel. Electricity as a source of energy is not available in the underdeveloped villages. Differences in propensities to spend on other local fuel products, such as jute sticks, rice husks, and dry leaves, are conditioned by a host of factors. For example, use of rice husks is almost three times greater in underdeveloped areas due to rice being processed at home, while in developed areas, rice is processed in mills, which results in the loss of rice husks for fuel. Similarly, jute sticks are more likely to be used for fencing than for fuel in underdeveloped areas.

*Other Manufactured Consumer Goods, Including Clothes.* The average budget share for this broad group of commodities is 12 percent larger in developed areas, but the marginal budget share is only 6 percent larger. This has resulted in a slightly higher expenditure elasticity for this commodity group in underdeveloped villages. However, the expenditure elasticity is generally quite high in both groups of villages. It appears that the propensity to spend on handloomed clothes is higher in underdeveloped villages.

*Services.* The average budget share for services in the developed group is about three times the average share in the underdeveloped group. The marginal budget share is about 160 percent larger in the developed group, resulting in an expenditure elasticity for services of 1.7 in developed areas and 3.0 in underdeveloped. It is worth noting that the propensity to spend on religious services is quite high in developed areas. The propensity to spend on health and medical services is also higher in developed villages.

In sum, it appears that infrastructure development leads to a reduction in the share of income spent on food and an increase in the share spent on nonfood items. The average share of income spent on food is 75 percent in the developed areas and 81 percent in the underdeveloped. This change results from a sharp reduction in the share spent on cereals (a share that averages 48 percent in developed areas and 60 percent in underdeveloped areas). However, the average share of noncereal foods increases modestly due to infrastructure development (the average share of noncereal foods is 27 percent in developed areas and 21 percent in underdeveloped). This change in the composition of the food basket does not lead to any loss in nutritional status for the people in the developed villages. A nutritional analysis based on this data is presented in a separate paper by Kumar (1988). A summary of broad sources of nutrition by infrastructural groups is presented in Table 36.

An analysis of calorie intake by infrastructural group indicates that at given levels of expenditure, residents of the developed villages derived an average of 1,768 calories from cereals (74 percent of 2,387 total calories), compared with 1,800 calories per capita of cereals consumed in underdeveloped villages (81 percent of 2,232). Assuming that calorie content per unit of cereal is the same in the two groups of villages, higher prices as the result of infrastructure development are perhaps partly responsible for cereals' smaller share of total expenditure in developed villages.

How much of the difference in cereal consumption at the same income level at higher levels of infrastructure development can be attributed to changes in taste and how much to differences in price levels is an interesting question. In order to derive

**Table 36—Broad sources of calorie intake by infrastructure groups, 1982**

| Infrastructure Group | Total Calories per Capita | Share of Cereals in Total Calories | Share of Noncereals in Total Calories |
|---|---|---|---|
| | | (percent) | |
| Three most developed villages | 2,387 | 74.08 | 25.92 |
| Three most underdeveloped villages | 2,232 | 80.67 | 19.33 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

an answer, the price effect (the effect of the price difference) is estimated and then this effect is deducted from the total infrastructural effect to obtain the effect of a change in taste as a residual. This change of taste is analogous to that observed in the process of urbanization. However, price differences between developed and underdeveloped areas are not straightforward. Analysis of village-level data indicates that rice prices (averaged over the whole year) are 5.7 percent higher in developed than underdeveloped areas. But the preharvest rice price is about 2 percent higher in underdeveloped than developed villages. Using the annual average price difference and a price elasticity of demand of 0.45, it is estimated that the price effect is rather small, and most of the difference in cereal consumption between the developed and the underdeveloped villages can be attributed to change in taste presumably brought about by infrastructure development. The estimated difference in consumption of cereals would have been 22 percent between the developed and underdeveloped villages if price levels were the same. Because of the price effect and the taste effect, the actual difference is 24 percent (see Table 37).

In general, the demand for cereals and fuels is inelastic and the demand for all other commodities is elastic. The expenditure elasticity is largest for services, followed by consumer goods and livestock and fish products. Infrastructure development reduces the expenditure elasticity of cereals but enhances the elasticity of all other products except milk and milk products.

## Consumption Pattern by Income Quartile and Infrastructural Status

The analysis of income quartiles has been conducted by ranking all households in 16 villages according to per capita income and then dividing the sample into quartiles. Consumption functions are estimated for each quartile using the infrastructural index as one of the Z variables along with the other usual variables.

The consumption pattern of the households in the four income quartiles is shown in Table 38. As expected, the households in the first income quartile (with the lowest

**Table 37—Per capita consumption of cereals in developed and underdeveloped villages after adjustment for price effect, 1982**

| Item | Underdeveloped Villages | Developed Villages | Difference[a] |
|---|---|---|---|
| | | | (percent) |
| Per capita total expenditure on consumption (Tk) | 2,706 | 2,706 | 0 |
| Per capita consumption of cereals (kilograms) | 230 | 174 | 24.3 |
| Per capita consumption after adjusting for the price difference[b] (kilograms) | 230 | 179 | 22.2 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Underdeveloped − Developed)/Underdeveloped] × 100.

[b] To adjust, consumption in developed villages is raised by 2.57 percent, which equals the annual average price difference times the price elasticity of demand (5.7 × 0.45 = 2.57).

### Table 38—Average (ABS) and marginal (MBS) budget shares, by income quartiles, in developed and underdeveloped villages, 1982

| | First Quartile | | | | Second Quartile | | | |
|---|---|---|---|---|---|---|---|---|
| | Developed | | Underdeveloped | | Developed | | Underdeveloped | |
| Consumption Item | ABS | MBS | ABS | MBS | ABS | MBS | ABS | MBS |
| | (percent) | | | | | | | |
| Cereals | 64.00 | 53.77 | 62.91 | 55.91 | 43.03 | 40.54 | 60.34 | 57.41 |
| Field crops (potatoes, vegetables, pulses, spices) | 9.26 | 3.83 | 9.23 | 12.04 | 8.92 | 4.94 | 6.8 | 6.67 |
| Narcotics[a] | 3.46 | 5.47 | 1.05 | 2.86 | 4.45 | 5.49 | 2.11 | 3.30 |
| Sugar | 0.80 | 2.37 | 0.84 | 1.16 | 2.04 | 2.87 | 0.94 | 0.96 |
| Oils and fats | 2.24 | 2.59 | 2.96 | 5.59 | 2.32 | 2.07 | 2.04 | 1.70 |
| Fruits | 0.57 | 1.24 | 1.29 | 2.02 | 1.14 | 1.23 | 0.56 | 0.71 |
| Tea | 0.90 | 1.15 | 0.01 | 6.24 | 1.30 | 1.05 | 6.00 | 6.00 |
| Fish and livestock | 1.98 | 5.64 | 3.48 | 8.05 | 10.11 | 7.27 | 4.83 | 9.29 |
| Total food | 83.21 | 76.05 | 81.77 | 87.87 | 73.31 | 65.46 | 77.63 | 80.04 |
| Energy and fuels | 8.74 | 6.79 | 10.87 | −2.12 | 8.39 | 8.88 | 12.23 | 7.87 |
| Consumer goods | 5.25 | 10.87 | 4.51 | 9.52 | 5.74 | 10.63 | 8.37 | 10.71 |
| Services | 2.86 | 6.71 | 2.81 | 4.71 | 12.51 | 15.02 | 1.77 | 1.34 |
| Total nonfood | 16.85 | 24.37 | 18.20 | 12.11 | 26.64 | 34.53 | 22.37 | 19.92 |
| Total | 100.07 | 100.44 | 99.97 | 99.98 | 99.95 | 99.99 | 100.00 | 99.96 |

| | Third Quartile | | | | Fourth Quartile | | | |
|---|---|---|---|---|---|---|---|---|
| | Developed | | Underdeveloped | | Developed | | Underdeveloped | |
| Consumption Item | ABS | MBS | ABS | MBS | ABS | MBS | ABS | MBS |
| | (percent) | | | | | | | |
| Cereals | 28.46 | 14.91 | 57.55 | 54.96 | 26.16 | 9.36 | 55.59 | 44.50 |
| Field crops (potatoes, vegetables, pulses, spices) | 9.17 | 12.80 | 7.58 | 11.18 | 9.31 | 8.59 | 10.08 | 12.56 |
| Narcotics[a] | 4.49 | 2.34 | 3.27 | 2.97 | 3.87 | 5.33 | 2.55 | 1.26 |
| Sugar | 1.28 | 2.81 | 0.55 | 1.29 | 2.52 | 4.84 | 1.44 | 2.27 |
| Oils and fats | 2.06 | 2.99 | 1.54 | 1.73 | 3.31 | 4.17 | 2.20 | 3.72 |
| Fruits | 2.14 | 2.09 | 2.05 | 2.15 | 2.53 | 2.96 | 1.18 | 1.85 |
| Tea | 1.35 | 2.69 | 0.01 | 0.14 | 0.94 | 0.74 | 0.02 | 0.02 |
| Fish and livestock | 9.44 | 16.06 | 5.47 | 4.60 | 10.60 | 18.18 | 7.68 | 15.50 |
| Total food | 58.42 | 56.69 | 78.02 | 78.74 | 59.24 | 54.17 | 80.74 | 81.09 |
| Energy and fuels | 12.71 | 9.26 | 8.30 | 4.30 | 8.12 | 6.31 | 6.40 | 2.47 |
| Consumer goods | 16.13 | 11.86 | 10.07 | 10.64 | 15.73 | 11.85 | 9.61 | 10.59 |
| Services | 12.75 | 22.19 | 3.61 | 6.15 | 16.91 | 27.67 | 3.25 | 5.85 |
| Total nonfood | 41.59 | 43.31 | 21.98 | 21.09 | 40.76 | 45.83 | 19.26 | 18.91 |
| Total | 100.01 | 100.00 | 100.00 | 99.83 | 100.00 | 100.00 | 100.00 | 100.00 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

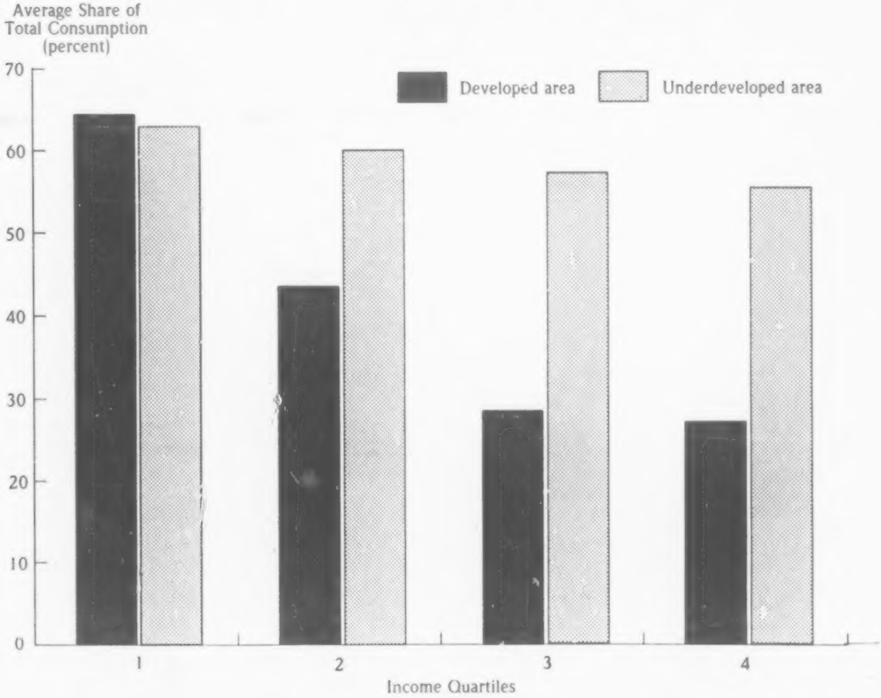
Note: Totals may not add up to 100 percent because of rounding.

[a] The narcotics included in this data are biri, cigarettes, betel leaf and nuts, tobacco, and jarda.

level of income) have high average and marginal shares for cereals in particular and for agricultural products in general. As households move up the income scale, this pattern reverses so that in higher income quartiles, households tend to allocate proportionately more for nonfood and less for food, particularly cereals. This change in the propensity to consume accompanying a change in income has important implications for economy-wide linkage effects related to consumption expenditure. First, policies that create special income advantages for low-income households are likely to have a proportionately larger impact on the demand for cereals than policies favoring high-income households. This implies an upward pressure on cereal prices, particularly in the context of inelastic supply and a closed economy. In an open economy, the actual increase in cereal prices may not occur at all, but the net import of cereals must increase to counter the tendency of prices to increase. Second, the total linkage effect of household expenditure is largely determined by the sizes of the marginal and average propensities of consumption. These propensities are larger in higher income quartiles for noncereal foods and nonfoods. Because of those relations, policies that favor higher income households may generate larger linkage effects than policies that favor low-income households.

Examination of the consumption pattern by infrastructural groups shows that reduction in the propensity to consume cereals resulting from development of rural infrastructure comes about mainly through changes in household consumption patterns in the second through the fourth income quartiles (see Figure 3). Infrastructure development does not appear to make any significant difference in the propensity to consume cereals in the lowest income quartile.

**Figure 3—Average propensity to consume cereals by income quartile in infrastructurally developed and underdeveloped villages**



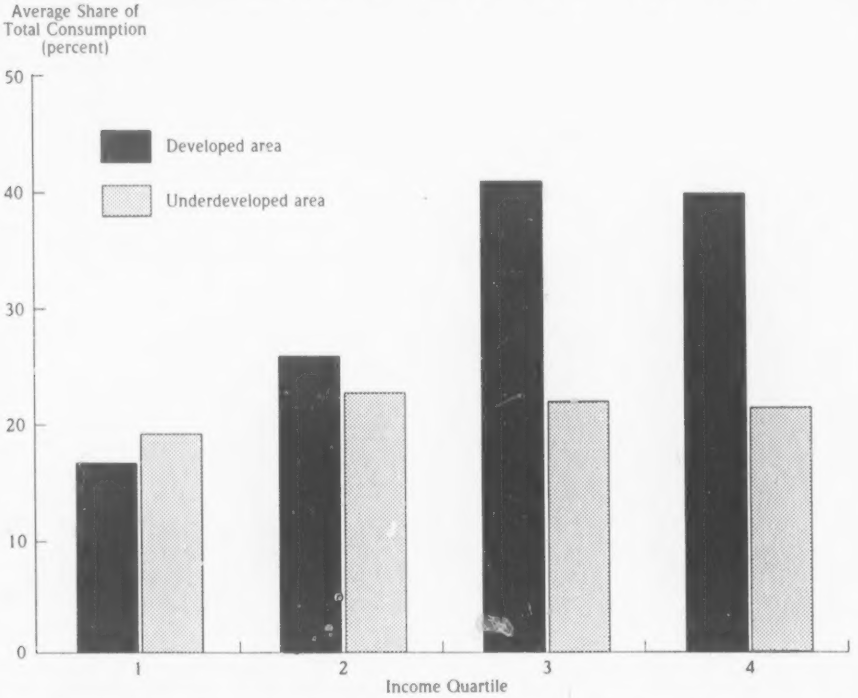
Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: Quartile 1 is the household group with the lowest total expenditures and Quartile 4 is the group with the highest total expenditures.

The effect of infrastructure development on the propensity to consume nonfood goods and services is portrayed more clearly in Figure 4. Note that these effects by income quartiles have been estimated by keeping the income level in each quartile the same for both developed and underdeveloped areas. Therefore, the effects reflect changes in taste patterns, as well as in price levels, caused by infrastructure development. In developed areas, the sharply increasing trend in budget share for nonfood goods and services contrasts sharply with the pattern in underdeveloped areas, where the shares maintain a virtually flat trend. How much of this difference is due to changes in taste and how much to differences in price levels could not be ascertained in the same way as for cereals. Village-level prices of nonfoods were not collected as scrupulously as those for rice.

Household behavior in consumption of nonfoods, as reflected by expenditure elasticities in various quartiles of developed areas, is quite puzzling (Appendix Table 77). The expenditure elasticities are in decreasing order with 1.45 for the first quartile and 1.12 for the highest income quartile. This is obviously a result of relatively larger marginal budget shares in the first two quartiles. Such a phenomenon could possibly

**Figure 4—Average share of nonfood expenditures by income quartiles in infrastructurally developed and underdeveloped villages**



Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: Quartile 1 is the household group with the lowest total expenditures and Quartile 4 is the group with the highest total expenditures.

be the result of the occupational distribution among quartiles. It is generally believed that salaried persons adopt urban consumption styles faster than richer agriculture-based households. In developed areas, the increase of salaried employment among the landless and small and medium landowning households has been greater than that for large landowning households. Although a detailed analysis of this phenomenon, as discerned by examining expenditure elasticities of nonfoods in developed areas, could not be pursued in the present study, the hypothesis is still worth pursuing in the future.

## Conclusions

A number of important implications for infrastructure development, with economy-wide repercussions for household expenditures, have already been discussed. The empirical evidence presented has substantiated some of these implications.

First, the difference in the marginal propensity to consume between households located in infrastructurally developed and underdeveloped areas implies that infrastructure development induces increases in demand for noncereal foods and nonfood consumer goods and services. The effect on overall interindustry production, employment, and income linkages is bound to be substantial, largely because infrastructure development enhances income from various sources as shown in Chapter 6. By spending a larger share of this incremental income on noncereal foods, nonfoods, and services, households in developed areas generate additional employment and income in the economy during the subsequent rounds of activity. In addition to the income effect, infrastructure development clearly diminishes the propensity to consume cereals and increases the propensity to consume nonfood goods and services through a change in taste patterns. These changes are congenial for development of a diversified rural economy.

Second, full realization of potential linkage effects from increased final demand depends on how the supply of goods and services responds to changes in demand. Most analyses of intersectoral linkages employ a static framework of input-output tables. This approach assumes that supply is infinitely elastic, and therefore an increase in final demand is not accommodated by increased prices but in increased production and supply. Infrastructure development plays a critical role in upholding the degree of validity of this assumption and thus the amount of realized benefit from intersectoral linkages. Infrastructure development increases the speed of diffusion of agricultural technology, reduces the cost of marketing, and improves the operation of both factor and product markets. The positive influence of these changes implies a greater degree of supply response in infrastructurally developed areas.

# 8

# INFRASTRUCTURE AND SAVINGS-INVESTMENT BEHAVIOR

The savings rate, marginal or average, is a key factor in sustaining a self-reliant pace of economic growth. Furthermore, savings are required for investment; unless this transformation of savings into investment is complete, the impact of savings on economic growth may not be perceptible. Household savings, exclusive of transfer payments, are a component of national savings frequently featured in macroeconomic policies. Knowledge of household savings and investment is critically important, not only for correctly assessing aggregate savings but also in formulating development policies. Formulation of policies designed to increase the propensity to save and invest has suffered from the dearth of knowledge about savings and investment behavior in households of developing countries. Moreover, positive price policies are common in most developing countries. The degree of supply response to changes in price policies greatly depends on whether and how the price-induced increment in income is saved and invested. This section is devoted to analysis of the impact of rural infrastructure on the savings and investment behavior of rural households within the context of a range of factors that are common in savings and investment functions. Thus, in addition to measuring the effects of infrastructure development, the study describes the nature of savings and investment propensities and patterns in rural households of Bangladesh.

## Conceptual and Measurement Issues

Savings and investment in developing-country households are closely interrelated with production and consumption decisions. This interaction compounds the general problem of definition and measurement of household savings and investment flows.

### Income

Although the concept of household income was explained in Chapter 6, further explanation is necessary in the context of this analysis. Two additional concepts for the measurement of income are introduced here. First, the income variable for labor involved in the creation or improvement of physical assets, including land development, is modified by adding the value of family labor, using the prevailing market wage rate. In Chapter 6, measurement of income from production excludes family labor used in production activities; income is measured as a return to family labor and owned assets. However, if construction of new assets using family labor is included in the savings and investment accounts, as defined here, then it is appropriate that this component of family labor be included in income. Second, the income flow measured from the production accounts does not always match income measured from the expenditure accounts, which define gross income as the sum of expenditures on consumption and on various savings, based on data obtained directly from the survey. Conceptually, the gap between the two income estimations should be explained by the balances of financial and credit accounts, but empirically this gap may persist due to measurement errors in data. In Table 39, which uses both estimates of income, the average savings

## Table 39—Average rate of gross savings in households in 16 villages, 1982

| Village | Average Rate Based on Production Accounts[a] | Average Rate Based on Expenditure Accounts[b] | Number of Cases |
|---|---|---|---|
| | (percentage rate) | | |
| Charkhamar | 9.3 | 11.2 | 38 |
| Rajarampur | 8.7 | 10.1 | 40 |
| Syedpur | 11.7 | 11.1 | 40 |
| Gobindapur | -1.3 | -1.8 | 40 |
| Bandabeel | 22.7 | 21.8 | 39 |
| Raokuli | 6.6 | 7.9 | 39 |
| Harispur | 18.4 | 20.3 | 40 |
| Gobrapara | 2.6 | 2.6 | 39 |
| Birhat | 22.6 | 18.8 | 40 |
| Taliamara | 26.4 | 23.7 | 40 |
| Khejurdanga | 5.0 | 6.9 | 36 |
| Khunta | 9.9 | 7.5 | 40 |
| Illashpur | 23.1 | 17.6 | 40 |
| Chashapara | 22.9 | 23.3 | 39 |
| Patgari | 2.2 | 2.8 | 40 |
| Raotara | 5.6 | 6.9 | 38 |
| Developed | 15.1 | 14.9 | 271 |
| Underdeveloped | 13.2 | 12.6 | 357 |
| All villages | 14.0 | 13.6 | 628 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] This average rate is obtained by dividing gross savings by the income measured from production accounts.

[b] This average rate is obtained by dividing gross savings by the income measured from expenditure accounts.

rates do not differ much. This will be analyzed further later in this chapter when a profile of rural savings is presented.

## Savings

Savings of a household can be defined as the surplus of current income after deducting current consumption expenditures. This measurement approach for savings is not very revealing, however, and the estimate of savings thus measured may mask considerable errors in the estimates of income, shedding little light on underlying real propensities to save.

The savings of a household can be more meaningfully defined as the change in net worth and computed as the difference between the change in the value of assets and the change in liabilities. This figure has to be adjusted for capital transfer. In other words, household saving SH is defined as

$$SH = PA + FA - dL,$$

where

PA = gross change in the value of physical assets,
FA = gross change in the value of financial assets, and
dL = net change in liabilities including net inflow of capital transfer.

It should be noted that determining the *change* in the stock of assets and liabilities—not their current levels—is the main objective of the measurement. This measurement can be obtained in two ways. Adopting a balance sheet approach, one can measure the value of assets and liabilities twice—once at the beginning and once at the end of a reference period (generally one year) and take the difference between the two measures as the estimate of gross savings. There is no need to estimate separately the extent of damage or destruction of assets if this balance sheet method is adopted.

In the second method, net acquisition of assets and changes in liabilities are directly measured from the household surveys designed to collect data on expenditures, lending and borrowing, sales and purchase of assets, construction of assets using family labor, damages and destruction of property, and so forth. This second method is followed in the estimation of savings and investments in the present study.

The following accounts from the household surveys are considered in the estimation of savings:

1. Physical assets
    - Land acquisition (purchase minus sale)
    - Construction of houses
    - Consumer durables
    - Excavation of ponds for fisheries and purchase of fishing nets
    - Improvement or additional planting minus sales or use of trees
    - Land development, including irrigation
    - Transport equipment (purchase minus sale)
    - Agricultural implements (purchase minus sale)
    - Other equipment (purchase minus sale)
    - Equipment for rural industries (purchase minus sale)
    - Sanitary and drinking water facilities (purchased, repaired, and developed through family labor)
    - Net acquisition of livestock (purchase minus sale)
    - Repair of implements
    - Business investment (net addition to business assets, such as shops)
2. Purchase of financial instruments
3. Net increase in credit given including mortgage transactions

The third item is estimated by adding credit given in the current year and repayment of past credit in the current year, including land mortgages, and deducting from this sum the amount of credit received from all sources, including land mortgages. The estimate of gross savings is arrived at by adding 1 through 3 in the list and deducting from this sum the estimated value of damage to or destruction of property.

It is clear from the list that changes in inventories of commodities, cash holdings, and gold are not included. This information could not be obtained from households despite efforts toward this end. It must, however, be reiterated that it is the changes in levels of these excluded items that matter in the estimation of savings. Such changes are likely to be small. Thus, exclusion of these items may not be a serious concern in providing a rough order of the magnitude of gross savings in rural Bangladesh.

However, inclusion of certain items as saving activities in the list requires some explanation. Consumer durables have been treated as part of savings and investment. In the literature, it is controversial whether this item should be treated as consumption or investment expenditure. The close interdependence between production and consumption activities in rural households of Bangladesh further compounds the problem. For this study, it was arbitrarily decided to treat consumer durables as an investment. Repair of implements to maintain them in working condition should generally be considered a production expense and included in current costs, but households often responded that such repairs increase the working life of the implements. Therefore, the distinction between repair costs incurred to prolong the working useful life of implements and those made in order to keep the implements in current use could not be made easily. However, those repair costs that households reported were undertaken to enhance the working life of implements were included in savings and investments.

It is particularly complicated to estimate savings and investment in the case of livestock. Ideally, the birth of new livestock minus deaths plus net acquisition through purchase and sale should be considered. However, it was not possible to collect information on births and deaths of livestock. The estimate based on purchase minus sale gives an average that is almost zero for the entire sample, but that for individual households varies widely, some having positive and some negative values.

A comparison of 1960 and 1982 pilot agricultural census figures on the number of livestock indicates an annual growth rate of 0.4 percent for cattle, 3.5 percent for sheep and goats, and 5.5 percent for poultry. On the basis of 1982 constant prices, the annual growth rate for the livestock sector is estimated to be only 0.95 percent during the intercensal period. The average value of livestock per household at the beginning of the survey year of the sample was Tk 1,450. If this stock is assumed to have grown by 0.95 percent, then the increase in stock per household would be equivalent to Tk 14. This is 0.07 percent of the average income per household. Thus, the gross savings rate, on the basis of this alternative, underestimates livestock accounts by only 0.07 percentage points. In other words, if livestock assets in the sample increased in number at a pace equal to that between the 1960 and 1982 agricultural censuses, then the average gross savings rate of the sample households would have been 13.67 percent instead of 13.60 percent as shown later. It seems that the margin of error on the livestock account, by not properly accounting for births and deaths of livestock, is rather small.

There is a conceptual difference between savings at the household level and at the national level. The national estimate of household savings must exclude transfer payments and include adjustments for export and import (see Alamgir 1976). Buying land represents a saving for the purchasing household but a dissaving for the selling household, so that national saving is zero. The case is similar for credit and many financial assets. The items listed earlier under physical assets (excluding land) and investment on education would be approximately equivalent to the contribution of rural households to national savings. These components are examined further in the context of capital accumulation. An analysis of capital accumulation or investment in physical assets and education will be conducted at the end of this chapter, using the sum of savings from the physical assets (excluding land acquisition) in the list provided earlier.

## A Descriptive Profile of Rural Savings

Investments in assets such as houses, tubewells, boats, rickshaws, and shops are too lumpy for the level of income of most households. A typical household can only invest in such assets once or twice in a lifetime through continuous accumulation of savings. A richer household can make more frequent investments than a poorer one.

Certain investments are skill specific. A household will invest in a boat or a shop or fishing equipment depending on the aptitude and entrepreneurship of its household members. Different investments entail different degrees of risk from natural forces as well as economic ones. Investment in land (either through purchase or through mortgage) is considered to be the least risky investment in rural Bangladesh. These diversities in household investment behavior are microrealities, from which this study proposes to abstract some average indicators to portray the extent and the nature of savings and investment in the rural household economy of Bangladesh.

## Average Savings Rate in Households

The estimated average rate of savings for the 16 villages in Table 39 varies little between the two estimates—14.0 to 13.6 percent—although, the variation between the average rates is less modest in some villages, in Illashpur, for example. This variation between the two measures of income is expected to be larger at the household level because of wide diversity in the measures that households undertake to finance expenditures when income is destabilized. On average, the savings rate based on income from the production account is slightly higher than the rate based on income from the expenditures account, because the estimate of income from production is slightly lower than that from expenditures. Even though the average savings rate based on expenditure is about 13.6 percent, this rate varies widely among villages. Gobindapur, for example, has a negative average savings rate, whereas Taliamara, Chashapara, and Bandabeel have savings rates ranging from about 22 to 24 percent. Infrastructurally developed villages show a slightly higher rate of savings than underdeveloped villages.

The most significant result of this analysis of the average savings rate is the distribution of savings in rural areas. About 36 percent of the households are found to have a zero or negative savings rate (Appendix Table 78). But negative savers are not limited to the lowest income quartile; about 12 percent of households in the top income quartile also have no savings. Although about 57 percent of the households in the lowest income quartile are nonsaving, about 4 percent in this quartile have a savings rate of more than 10 percent. On the whole, only about 29 percent of the households in the sample save that much.

Distribution of saving and nonsaving households by landownership groups provides further insights on savings behavior (Appendix Table 79). In developed villages, about 71 percent of the landless households are savers (therefore 29 percent are nonsavers), compared with underdeveloped villages where only about 59 percent of landless households are savers. Apparently not all landless households are as poor as is generally thought, and infrastructure development seems to be positively associated with a relatively better-off position for this group. In fact, both the landless and large-owner groups have significantly more savers in developed than in underdeveloped villages. Among the small and medium landowners, however, the proportions of savers and nonsavers are not significantly different.

Among the households that have positive savings rates, the distribution of total savings is extremely skewed—more skewed than income distribution. Households in the top decile generate about 60 percent of the total gross savings in rural areas. The top two deciles together share about 75 percent of the total savings. Households in the lowest two deciles generate less than 2 percent of the total rural savings. On the other hand, the top 20 percent of households receive about 43 percent of total income, whereas the lowest 20 percent receive about 10 percent of total income.

This skewness in distribution of savings in rural areas has important implications for policies to mobilize resources in the rural sector. The role of rural banking and taxation policies is particularly relevant in encouraging savings. Although average per capita income is generally low, this is a weak indicator of potential funds for savings or taxation. A relatively small number of households do possess a substantial potential for mobilization of financial resources in rural areas.

## Composition of Gross Savings

Two broad components of the total gross savings per household—capital formation and transfer-type savings—are shown in Table 40. Investments in physical assets, excluding land purchases but including human capital development, are classified in the broad group of capital formation. Net lending, net land purchase, and purchase of financial instruments are classified as transfers. Investment in financial instruments, strictly speaking, cannot be considered entirely a transfer, but since it is so small (only about Tk 6.0 per household) and its main component is a transfer, it is treated as such.

Capital formation, averaged over the whole sample, constitutes about 78 percent of gross household savings. The remaining 22 percent is invested in transfer-type activities, which implies a net movement of capital resources out of the sample households. Most of these transfers are brought about through land purchases (46 percent of total transfers) and lending on land mortgages (50 percent); other types of lending account for the other 4 percent. Allocation of savings between capital formation and transfer-type investments differs between developed and underdeveloped groups—moderately in capital formation and substantially in transfer-type investment.

Even though the average share of capital formation in total saving is only 78 percent, variation among villages in this respect is quite large. Three out of 16 villages had capital formation far above gross savings, implying increased borrowing by households

**Table 40—Composition of gross household savings, 1982**

| Village | Average Savings/ Household | Capital Accumulation/ Household | Transfer-Type Savings/ Household | Capital Formation as a Percent of Savings | Transfer as a Percent of Savings |
|---|---|---|---|---|---|
| | | (Tk) | | (percent) | |
| Charkhamai | 2,497 | 1,305 | 1,192 | 52.3 | 47.7 |
| Rajarampur | 2,023 | 496 | 1,527 | 24.5 | 75.5 |
| Syedpur | 2,227 | 585 | 1,642 | 26.3 | 73.7 |
| Gobindapur | −250 | −61 | −189 | 24.4[a] | 75.6[a] |
| Bandabeel | 5,621 | 1,334 | 4,287 | 23.7 | 76.3 |
| Raokuli | 1,248 | 646 | 602 | 51.8 | 48.2 |
| Harispur | 5,803 | 3,373 | 2,430 | 58.1 | 41.9 |
| Gobrap | 435 | 3,186 | −2,751 | 732.4 | −632.4 |
| Birhat | 3,996 | 4,161 | −165 | 104.1 | −4.1 |
| Taliamara | 4,422 | 4,053 | 369 | 91.7 | 8.3 |
| Khejurdanga | 720 | 509 | 211 | 70.7 | 29.3 |
| Khunta | 1,504 | 1,959 | −455 | 130.3 | −30.3 |
| Illashpur | 5,229 | 4,265 | 964 | 81.6 | 18.4 |
| Chashapara | 7,245 | 6,124 | 1,121 | 84.5 | 15.5 |
| Patgari | 547 | 1,541 | −994 | 281.7 | −181.7 |
| Raotara | 983 | 898 | 85 | 91.4 | 8.6 |
| Developed | 3,118 | 2,317 | 801 | 74.3 | 25.7 |
| Underdeveloped | 2,523 | 2,019 | 504 | 80.0 | 20.0 |
| All villages | 2,779 | 2,161 | 618 | 77.8 | 22.2 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: A negative transfer implies increased indebtedness or money going out from a sample household, while a positive transfer implies receipt of money from outside the household.

[a] These are percentages of a total dissaving.

for the sake of capital formation. Such a phenomenon of large investment through borrowing occurs in only a small number of cases, but it inflates the village averages.

## Structure of Capital Formation

Since capital formation is the largest component of gross savings and roughly represents private rural savings in the national aggregate, a further disaggregation of this broad component is desirable. However, the estimate of capital formation does not include any allowance for wear and tear of existing capital stock.

The composition of capital formation in Table 41 shows clearly that rural households invest about 50 percent of their total capital formation in housing and consumer durables—40 percent in housing alone. Nonagricultural investment, the next largest share, is 33 percent, while agricultural investment is only about 17 percent. Land development and agricultural equipment account for most of the agricultural investment.

Gross capital formation per household is about 17 percent higher in the developed group than in the underdeveloped. The difference in investment in housing and durables between the two groups is similar. Developed villages have about 10 percent higher investment per household than underdeveloped, largely due to nonagricultural investment. It is in agricultural investment that the difference between the two groups stands out. The level of total investment in agriculture is about 47 percent higher in developed villages even though investment in irrigation and drainage and agricultural equipment is about 21 percent lower. This is the consequence of a large difference between the two groups in investment in livestock and fisheries, which is extremely high in developed villages. Underdeveloped villages are more likely to disinvest than to invest in livestock.

The higher level of investment in irrigation and agricultural equipment in underdeveloped villages may seem surprising, but it is not so in reality. First, the land area

**Table 41—Structure of gross capital formation at the household level, 1982**

| Investment | Developed Villages | | Underdeveloped Villages | | Difference in Value[a] | All Households | |
|---|---|---|---|---|---|---|---|
| | Value | Share | Value | Share | | Value | Share |
| | (Tk) | (percent) | (Tk) | (percent) | (percent) | (Tk) | (percent) |
| Housing and durables | 1,269 | 49.4 | 1,123 | 51.1 | 13.0 | 1,189 | 50.3 |
| Consumer durables | 215 | . . . | 237 | . . . | −9.0 | 227 | 9.6 |
| Housing | 1,017 | . . . | 866 | . . . | 17.4 | 935 | 39.5 |
| Sanitation | 37 | . . . | 20 | . . . | 85.0 | 27 | 1.2 |
| Agricultural investment | 479 | 18.6 | 326 | 14.8 | 46.9 | 395 | 16.7 |
| Fisheries | 54 | . . . | 15 | . . . | 260.0 | 32 | 1.3 |
| Plantation | 10 | . . . | 25 | . . . | −60.0 | 18 | 0.8 |
| Livestock | 170 | . . . | −26 | . . . | . . . | 63 | 2.7 |
| Irrigation and drainage | 96 | . . . | 137 | . . . | −29.9 | 119 | 5.0 |
| Agricultural equipment | 149 | . . . | 175 | . . . | −14.9 | 163 | 6.9 |
| Nonagricultural investments | 821 | 32.0 | 749 | 34.1 | 9.6 | 781 | 33.0 |
| Transport | 24 | . . . | 37 | . . . | −35.1 | 32 | 1.3 |
| Industries and business | 797 | . . . | 712 | . . . | −11.9 | 749 | 31.7 |
| Total | 2,569[b] | 100.0 | 2,198[b] | 100.0 | 16.9 | 2,365[b] | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

[b] These figures differ slightly from the figures in Table 40 because property damage, theft, and certain disinvestments were deducted from gross savings in Table 40. The figures in this table do not incorporate those deductions because the damage estimates were in aggregate form, not separable by investment groups.

per household is about 34 percent larger in underdeveloped villages, and these investments are crop- and land-related investments. Investment in irrigation and agricultural equipment per acre of owned land would not be higher in underdeveloped villages. Second, investment in irrigation and drainage in underdeveloped villages has a higher component of the value of family labor in gross cost, as will be shown later. These investments are really the result of greater utilization of family labor in underdeveloped villages, where the opportunity cost of labor is lower than that in developed villages.

An issue related to the structure and estimation of capital formation in rural households concerns the extent of nonmonetized investment. Of the total value of capital formation, about 12 percent in developed and 20 percent in underdeveloped groups occur in nonmonetized form (such as family labor and home-produced materials) (Table 42). Home-produced materials, such as bamboos, thatches, and jute sticks, are used only in housing. Only monetized factors are involved in nonagricultural investment. Family labor has the largest share (68 percent) of the total nonmonetized investment. The difference between developed and underdeveloped groups in creating assets using family labor is significant. Underdeveloped villages use 38 percent more family labor in creating such assets than developed villages. Use of family labor in creating agricultural assets (land development) is three times higher in underdeveloped than in developed villages.

## Determinants of Rural Savings and Investments

Following Keynesian tradition, studies on savings, particularly aggregate savings, generally focus on the measurement of average and marginal propensities to save. This focus on savings as a function of income alone is viewed by many development economists as inadequate for explaining saving and investment behavior in developing countries. (See the review by Mikesell and Zinser 1973.)

Before discussing which variables in addition to income should be considered in savings-investment functions, a number of cautionary notes are in order to ensure that comparison of results among studies does not lead to inaccurate conclusions. First,

**Table 42—Extent of nonmonetized investment in gross capital formation, by infrastructural group, 1982**

| | Housing and Durables | | Agricultural Investment | | Nonagricultural Investment | | All Types | |
|---|---|---|---|---|---|---|---|---|
| Type of Investment | DV | UNDV | DV | UNDV | DV | UNDV | DV | UNDV |
| Gross investment (Tk) | 1,269 | 1,123 | 479 | 326 | 821 | 749 | 2,569 | 2,198 |
| Family labor (Tk) | 198 | 114 | 47 | 150 | . . . | . . . | 245 | 264 |
| Share in gross | (15.6) | (10.2) | (9.8) | (46.0) | . . . | . . . | (9.5) | (12.0) |
| Own materials (Tk) | 69 | 170 | . . . | . . . | . . . | . . . | 69 | 170 |
| Share in gross | (5.4) | (15.1) | . . . | . . . | . . . | . . . | (2.7) | (7.7) |
| Total nonmonetized (Tk) | 267 | 284 | 47 | 150 | . . . | . . . | 314 | 434 |
| Share in gross | (21.0) | (25.3) | (9.8) | (46.0) | . . . | . . . | (12.2) | (19.8) |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Ellipses (. . .) indicate insignificant values or zero. DV is developed villages; UNDV is underdeveloped villages. Numbers in parentheses are percentages.

savings and investment at both the household and aggregate levels fluctuate tremendously from year to year due to fluctuations in production and income. Variations in savings are much larger than variations in income because consumption demand takes priority over investment demand in low-income economies (Malenbaum 1962). Second, estimates of savings from micro and macro studies differ not only because of the definitional differences explained earlier but also because of the nature of the data involved. The difference in data is particularly reflected in the much wider range of the values of variables in micro studies. Unless appropriate specification of functional forms takes care of this difference in range of values, estimates of marginal propensities to save (MPS) obtained from the two types of studies could be very different. Similar differences generally exist between studies that use group averages of cross-sectional data compared with studies that use data for individual households. Generally the estimate of MPS from the former is smaller than the one from the latter. Studies based on detailed household information rather than group averages are quite rare in literature.

### Income

That income is the principal determinant of the propensity to save is well recognized. The relative roles of current income and permanent income in influencing savings behavior have drawn the attention of many researchers (Alamgir 1976). Data available in this study are not suitable for testing the permanent income hypothesis and therefore empirical results on this count are not discussed. Alamgir (1974), using aggregate data for 1960 to 1970, regressed per capita savings with per capita income separately for rural and urban areas of Bangladesh and estimated the MPS to be 11 percent for rural areas and 21 percent for urban areas. Malenbaum (1962) estimated the MPS in the Indian economy, using aggregate data, to be 30 percent during the early 1960s. From cross-section data for record-keeping farmers in Taiwan, Ong, Adams, and Singh (1972) estimated the MPS to be 35 percent in 1969 and 69 percent in 1966. Kelley and Williamson (1968) found the MPS to be 11 percent for farmers of Jogjakarta; this study also found the MPS of transitory income to be as high as 37 percent. There are numerous other studies on income and savings relations. In general, all studies indicate that the marginal savings rate is higher than the average.

### Assets or Wealth and Savings

Ownership of assets such as land and nonland capital stock is believed to influence positively the savings and investment behavior of households. A number of studies (Kelley and Williamson 1968; Desai 1969; Misra and Mallick 1969) have in fact found a positive relationship between the size of landownership and the propensity to save. It is, however, important to distinguish between the independent effects of assets and income, because asset ownership is generally positively correlated with income, thus confusing the independent effects of asset and income. Assets may represent a factor that underlies a household's expectation of future returns from asset accumulation. If past experience indicates that such assets generally bring normal returns or act as security in bad times, a household may accumulate such assets even in a year when returns are not particularly favorable.

### Rural Infrastructure

Inclusion of some measures of infrastructure development in rural savings and investment functions is rare. However, some studies that consider factors such as market structure, prices, and access to modern services do in fact recognize the importance of what is called infrastructure. Easy access to attractive consumer goods because of better infrastructure development may stimulate consumption expenditure more than savings and investment. On the other hand, easy access to more productive markets may stimulate income savings and investment. The balance of the two opposing effects cannot be forecast. Moreover, if most of the positive effect of infrastructure on investment behavior is realized through the income route (that is, through infrastructure influencing income and income influencing savings and investment), then a regression exercise to capture the independent effect of infrastructure may produce insignificant results.

The effect of infrastructure on investment in the local economy cannot be captured completely by measuring the effect only in local households. Infrastructure may induce investment from government as well as organized firms or even large households from outside the locality. Unfortunately, this data set does not include any economic unit other than local households. Therefore, the measurement of the effect of infrastructure through analysis of household income, savings, and investment is only a partial measure of the effect of infrastructure.

### Rate of Return from Investment

Rate of return from investment is accorded a crucial role in determining the level of investment and savings in all theoretical literature. But in empirical studies, virtually all those examined in connection with this analysis did not incorporate this variable, which is understandable in view of the complexities of obtaining a reliable measure of rate of return. Rural credit markets are so heterogeneous that construction of an index of interest rates in informal credit markets is practically impossible, except through a special research effort geared for this purpose. Moreover, it is the expected rate of return, not the actual, in any year that is the relevant variable. In any particular year, rate of return could even be negative, which an investor might expect to recover in another year. A satisfactory proxy of expected rate of return is hard to get. The closest proxy, perhaps, would be the amount of nonland capital that a household owns.

### Access to Technology

New technology increases the profitability of crops; therefore, farmers are expected to invest in structures and equipment that enable them to adopt new technology. It is also known that irrigation is a primary requirement for bringing new land under HYVs. Investment in tubewells and dug wells is a possible mechanism for expanding households' capacity to increase area under irrigation. On the other hand, if irrigation is publicly provided, as is generally the case with large-scale surface water and tubewell schemes, then water charges, if paid by the farmers, constitute the primary cost of irrigation; these are treated as current costs and not as investment. When a large farmer invests in a tubewell and then sells water to others, the water charges paid by farmers include both investment costs and operation costs. In the data for this study, these water charges appear as current cost for farmers purchasing water, but the installation cost of the tubewell is considered an investment by the large farmer. Technology also expands the scope for increasing income. Therefore, the income effect of technology on savings and investment is likely to be significant. This may mask the independent effect of technology.

### Other Explanatory Factors

In the literature on savings and investment, a significant number of other factors in addition to the ones discussed above are also postulated as important explanatory variables. Credit from institutional sources, demographic factors such as the dependency ratio and age of the household head, tenancy, and education are these factors, some of which are considered in this analysis.

Finally, a complete analysis of savings and investment behavior of rural households requires data that cover both time series and cross-section information. Without the time dimension, dynamic effects cannot be measured. Moreover, the real influences of many variables are accurately perceived only over a reasonable period of time. Similarly, the effects of structural variables are captured mainly through cross-section information. But data reflecting both structural and dynamic dimensions are rarely available for any developing country. The results presented below should be judged keeping this limitation in mind.

## Analysis of Savings-Investment Function

On the basis of the foregoing discussions, the following savings-investment function is postulated and estimated using regression techniques.

SINV = f(INCM, INF, EDCN, SCPT, FSZ, WRKR, CRDTI, HYV, LAND, RRTA, RRTN),

where

SINV = savings in taka per capita,
INCM = income in taka per capita,
INF = index of infrastructural underdevelopment (the higher the index number, the larger the degree of underdevelopment),
EDCN = education level of the head of household,
SCPT = stock of nonland capital in taka per capita,
FSZ = family size,
WRKR = number of working members in the family,
CRDTI = amount of credit per capita from institutional sources,
HYV = proportion of land under HYVs,
LAND = per capita land owned by the household,
RRTA = rate of return from agriculture measured as the ratio of agricultural income to nonland agricultural capital,
RRTN = rate of return from nonagriculture measured as the ratio of nonagricultural income to nonagricultural capital.

Initial examination of the data shows a wide range of values in SINV that indicate the appropriateness of quadratic or cubic terms of the income variable in the functional form. Households are grouped into landowning and landless classes. All households owning 0.5 acres or less of land are classified as landless.

Results of two specifications—one restricted to only income and infrastructure variables as explanatory factors and the other fully specified in the sense that all variables are included—are shown separately in the Appendix, Table 80. It is clear from comparing the two specifications that income is the dominant factor, and other variables excluding infrastructure contribute very little, as indicated by the difference in the values of the adjusted $R^2$. Income and its higher order terms are statistically highly significant. MPS is found to be quite high in farm households (46-56 percent) but relatively low in landless households (20-23 percent). Examination of the data indicates, however, that there are 10 households with extremely high levels of savings or dissavings in the sample. Excluding these 10 extreme households from the estimation of the equations results in little significant change in the adjusted $R^2$, but the estimated MPS for farm households is reduced significantly (Appendix Table 81). From 46-56 percent, the range of MPS for farm households is reduced to 32-42 percent. No change of MPS in landless households occurs due to the exclusion of extreme households. Clearly, concentration of savings and dissavings in a few hands makes overall savings behavior appear to be quite unstable.

Another disturbing aspect of the results emerges. Not only do the other variables (HYV, EDCN, CRDTI, WRKR, LAND, and so forth) contribute little overall to the explanation of per capita savings and investment, but most of their influence (except SCPT) is significantly different in direction than originally expected. Thus, inclusion of additional variables as explanatory variables tends to increase the MPS by about 10 points.

This result drives home the fact that savings and investment are very diverse in nature, and decisions on where to invest among these diverse groups are often interdependent. Savings are divided into four groups: (1) INVH (investment in housing, education, and durables), (2) INVA (agricultural investment), (3) INVN (nonagricultural investment), and (4) INVF (transfer-type investment). Thus four equations for four types of investment are formulated and estimated simultaneously, using Zellner's method of joint generalized least squares. The results for all households (shown in Tables 43 and 44) are quite stable and similar, even when extreme cases are excluded in Table 44.

The tables indicate that for investment in housing and durables, per capita income and family size are the two significant determinants. For agricultural investment, the income level and stock of nonland capital are the two positive factors, whereas per capita land owned appears to exert significant negative influence, rather robustly, in all regression equations. This could be brought about by households with higher land-man ratios renting out land and moving to nonagricultural occupations. It may also be true if the capacity for utilization of existing stock of capital in such households is low. The result seems to parallel the controversy that exists regarding the productivity differential between small and large farms.

That HYVs do not appear to be significantly related to agricultural investment may raise a question about how these new varieties can be grown without investment. The result really reflects the fact that most costs related to HYV are current costs. Chapter 4 shows that infrastructurally developed villages allocate about 71 percent more area to HYVs and use about 92 percent more fertilizer per unit of land than the underdeveloped villages. A comparison of current costs for irrigation and fertilizer between developed and underdeveloped villages is shown in Table 45. It is clear that current cost of irrigation is equal to about 18 percent of gross capital formation (or 81 percent of gross investment in agriculture) in developed villages. The current cost of irrigation in underdeveloped villages is equal to about 10 percent of capital formation. The difference in current cost for fertilizer between developed and underdeveloped villages is also large (65 percent).

Clearly, growing HYVs requires more working capital than fixed capital. This is partly due to the institutional arrangements for providing irrigation. Modern irrigation including tubewells is provided either by the government or occasionally by large

## Table 43—Regression results from simultaneous estimation of investment functions for all households

| Equation and Variable | Coefficient | t-Value |
|---|---|---|
| Equation 1: Investment in housing and durables (INVH) | | |
| INCM | 0.0797 | 6.684 |
| $(\text{INCM})^2$ | 0.246E-05 | 3.873 |
| $(\text{INCM})^3$ | −0.018E-09 | −3.853 |
| INF | −1.8328 | −0.377 |
| EDCN | −4.9617 | −1.332 |
| FSZ | 35.403 | 7.087 |
| Constant | −318.991 | −5.108 |
| Equation 2: Investment in agriculture (INVA) | | |
| INCM | 0.0428 | 2.454 |
| $(\text{INCM})^2$ | 0.304E-05 | 3.529 |
| $(\text{INCM})^3$ | 0.837E-10 | 1.213 |
| INF | 3.736 | 0.573 |
| HYV | −0.2045 | −0.411 |
| EDCN | −0.606 | −0.123 |
| WRKR | 13.541 | 0.699 |
| LAND | −4.365 | −6.959 |
| SCPTA | 0.1965 | 11.350 |
| CRDTI | −2.074 | −1.044 |
| RRTA | −0.1148 | −0.604 |
| Constant | −181.275 | −2.307 |
| Equation 3: Investment in nonagriculture (INVN) | | |
| INCM | 0.0585 | 3.607 |
| $(\text{INCM})^2$ | 0.366E-05 | 4.214 |
| $(\text{INCM})^3$ | −0.55E-10 | −0.877 |
| INF | −11.089 | −0.91 |
| EDCN | 11.29 | 2.266 |
| WRKR | −20.056 | −1.02 |
| LAND | −2.982 | −1.028 |
| SCPTN | 0.067 | 5.813 |
| CRDTI | −1.266 | −1.259 |
| RRTN | 0.257 | 0.983 |
| Constant | −128.349 | −2.650 |
| Equation 4: Transfer-type investment (INVF) | | |
| INCM | 0.2693 | 10.837 |
| $(\text{INCM})^2$ | −0.171E-04 | −12.923 |
| $(\text{INCM})^3$ | 0.151E-08 | 15.625 |
| INF | 8.214 | 0.821 |
| EDCN | −11.993 | −1.563 |
| LAND | −3.273 | −3.475 |
| Constant | −630.89 | −6.035 |

Estimated MPS is the sum of the MPS of four equations; MPS = 0.418.

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: INCM is income per capita; INF is infrastructure underdevelopment index; EDCN is education of head of household; FSZ is family size; HYV is share of land sown in high-yielding varieties; WRKR is number of workers per family; LAND is land owned per capita by household; SCPTA is stock of nonland, agricultural capital; SCPTN is stock of nonland, non-agricultural capital; CRDTI is credit per capita from institutional scources; RRTA is rate of return from agriculture; RRTN is rate of return from nonagriculture; and MPS is the marginal propensity to save.

## Table 44—Regression results from simultaneous estimation of investment functions for households, excluding 10 extreme cases

| Equation and Variable | Coefficient | t-Value |
|---|---|---|
| Equation 1: Investment in housing and durables (INVH) | | |
| INCM | 0.1088 | 2.056 |
| (INCM)$^2$ | −0.1305E-04 | −1.335 |
| (INCM)$^3$ | 0.115E-08 | 2.346 |
| INF | −2.5447 | −0.546 |
| EDCN | −3.5781 | −0.997 |
| FSZ | 31.2648 | 6.556 |
| Constant | −279.712 | −3.039 |
| Equation 2: Investment in agriculture (INVA) | | |
| INCM | 0.0428E-01 | 2.454 |
| (INCM)$^2$ | 0.304E-05 | 3.529 |
| (INCM)$^3$ | 0.837E-10 | 1.213 |
| INF | 3.7361 | 0.573 |
| HYV | −0.204 | −0.411 |
| EDCN | −0.606 | −0.123 |
| WRKR | 13.541 | 0.699 |
| LAND | −4.3648 | −6.959 |
| SCPTA | 0.1965 | 11.350 |
| CRDTI | −2.074 | −1.044 |
| RRTA | 0.114 | 0.604 |
| Constant | −181.275 | −2.307 |
| Equation 3: Investment in nonagriculture (INVN) | | |
| INCM | 0.0585 | 3.607 |
| (INCM)$^2$ | 0.366E-05 | 4.214 |
| (INCM)$^3$ | −0.55E-10 | −0.877 |
| INF | −9.054 | −0.823 |
| EDCN | 11.2923 | 2.266 |
| WRKR | −10.056 | −1.028 |
| LAND | −2.9817 | −4.852 |
| SCPTN | 0.067 | 5.813 |
| CRDTI | −1.266 | −1.253 |
| RRTN | −0.257 | −0.543 |
| Constant | −128.349 | −1.962 |
| Equation 4: Transfer-type investment (INVF) | | |
| INCM | 0.2692 | 10.837 |
| (INCM)$^2$ | −0.171E-04 | −12.923 |
| (INCM)$^3$ | 0.152E-08 | 15.626 |
| INF | 8.214 | 0.821 |
| EDCN | −11.993 | −1.563 |
| LAND | −3.273 | −3.475 |
| Constant | −630.89 | −5.029 |

Estimated MPS is the sum of the MPS of four equations; MPS = 0.34.

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: INCM is income per capita; INF is infrastructure underdevelopment index; EDCN is education of head of household; FSZ is family size; HYV is share of land sown in high-yielding varieties; WRKR is number of workers per family; LAND is land owned per capita by household; SCPTA is stock of nonland, agricultural capital; SCPTN is stock of nonland, non-agricultural capital; CRDTI is credit per capita from institutional scources; RRTA is rate of return from agriculture; RRTN is rate of return from nonagriculture; and MPS is the marginal propensity to save.

## Table 45—Comparison of current cost of irrigation and fertilizer between developed and underdeveloped villages, 1982

| Cost | Developed Villages | Under-developed Villages | Difference[a] |
|---|---|---|---|
| | | | (percent) |
| Irrigation cost (Tk/household) | 389 | 214 | 81.8 |
| Fertilizer cost (Tk/household) | 517 | 314 | 64.6 |
| Total irrigation and fertilizer costs (Tk/household) | 906 | 528 | 71.6 |
| Irrigation cost as a percentage of average capital formation | 17.5 | 10.1 | 73.3 |
| Fertilizer cost as a percentage of average capital formation | 23.3 | 14.8 | 57.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100.

farmers who invest in tubewells and sell water. The water charges paid by farmers have been treated as current costs in this study.

The rate of return measured by the income earned per unit of capital in a particular year of the survey does not show any significant influence on savings and investment propensity. But the rate of return, proxied by capital stock, has a highly significant degree of influence. As argued in the context of model specification, the rate of return in a dynamic setting reflecting multiple time periods and expectations is best proxied by capital stock. Therefore, the rate of return is a significant explanatory variable that influences propensities to save and to invest in both agricultural and nonagricultural opportunities. Besides income, the educational level of the household head and nonagricultural capital stock are principal explanatory factors for investment in nonagricultural assets. That the education variable is significant in nonagricultural investment but not in agriculture reflects the interaction of a number of factors in the economy of Bangladesh. The low level of technology, scale of farming, and the institutional setting do not make agriculture an attractive occupation for the educated. Nonagricultural occupations, on the other hand, require some basic education to conduct the tasks involved. Moreover, the long-term rate of return is probably higher in nonagriculture than agriculture.

Finally, the effect of infrastructure, the primary objective of this study, is found to have no significant direct contribution to investment and savings, even though the signs were as expected in all cases except agricultural investment. Therefore, the effect of infrastructure on savings and investment is indirect. The effect of infrastructure on income is the substantive effect that contributes to savings and investment via the income-savings relationship, which is robust. The MPS is estimated to range from 34 to 42 percent. When all households are included in the analysis, the MPS is 0.42, but when the 10 extreme households are excluded, the estimated MPS is 0.34 at the mean level of income.

The interesting aspect of the marginal propensity to save and invest is the differential propensities of various components. If the overall rural income increases by, say, Tk 10,000, about 34 percent of that amount (TK 3,400) is saved and invested by households. Of this amount, about Tk 600 (18 percent) is invested in housing, household durables, and education; Tk 300 (9 percent) is invested in agriculture; another Tk 500 (15 percent) is invested in business, transport, and industry; and the remaining Tk 2,000 (58 percent) is invested in transfer-type activities such as land purchases and lending, primarily lending on land mortgages. Therefore, the marginal propensity of capital formation is 14 percent and the marginal propensity of transfer-type savings is 20 percent. It is this 14 percent estimate of MPS that is comparable to the MPS generally measured from aggregate data of income and savings, because in macro-economic relations transfer-type savings would be zero.

## Conclusions

An attempt is made in this section to measure the influence of rural infrastructure on household savings and investment within a comprehensive framework that considers infrastructure along with other determinants. The analysis points up the complexity of estimating the savings rate at the household level. It is estimated that the average savings rate is about 14 percent, and this average rate is slightly higher in developed areas than in underdeveloped areas. About 35 percent of the households are found to have a zero or negative savings rate distributed over all income groups. Savings are extremely concentrated in a few households; 75 percent of the total gross savings are generated by households in the top two deciles of the income distribution.

Of the average level of savings, about 78 percent occurs in capital formation and 22 percent in transfer-type transactions. About 50 percent of capital formation takes place in housing and human resource development, 17 percent in agricultural capital, and 33 percent in nonagricultural assets. The extent of nonmonetized investment is about 17 percent of total capital formation; the proportion of nonmonetized investment is about 62 percent higher in underdeveloped than developed villages.

Gross investment per household is about 14 percent larger in developed than underdeveloped villages, even though investments in irrigation and drainage and agricultural equipment are 27 percent smaller in developed than in underdeveloped villages. This difference results largely from the difference in investments in livestock and fisheries. Developed villages invest a much larger amount in these two activities than do the underdeveloped villages. Moreover, the difference between investment in irrigation and agricultural equipment between the developed and underdeveloped villages disappears if investments are calculated on the amount of land owned rather than by the household. Landownership per household is about 34 percent larger in underdeveloped than developed villages.

Analysis of the determinants of savings and investment behavior in rural households indicates that current income is the dominant explanatory factor. Other variables contribute only marginally to the explanatory power. The effect of infrastructure is indirect through its effect on income and via income to savings. Estimates of the MPS vary from 34 to 40 percent. However, the marginal propensity for capital formation is much smaller than the MPS in transfer-type activities (such as lending and land purchase). The 34 percent estimate of MPS consists of about 14 percent from the marginal propensity for capital formation and 20 percent from the marginal propensity to save in transfer-type transactions. The 14 percent estimate is considered the equivalent of MPS for aggregate purposes (in the macroeconomic measure of household rural savings, for example).

The effect of infrastructure on diffusion of modern technology is found to be quite extensive in Chapter 4. It initially seemed surprising that it does not have a similar effect on agricultural investment related to the use of modern technology. Further analysis shows, however, that modern technology is highly intensive in current inputs and less so in fixed capital requirements, largely because of the institutional mechanism for supplying irrigation. The cost of irrigation (treated as a current input) is equivalent to about 18 percent of gross capital formation in developed villages. The cost of fertilizer is still higher than the cost of irrigation.

It should be noted that the average share of transfer-type investment is only 22 percent of the total gross savings, whereas the marginal share is about 59 percent. Thus, the opportunities for productive investment must be increased at an accelerated pace if the pressure on the demand side for transfer-type activities (lending through land mortgage, land purchases, money lending, and so forth) is to be reduced in the rural economy of Bangladesh. Infrastructure development along with other incentive policies—including institutional credit for the poor—will play a critical role in such a strategy of rural development.

# 9

# INFRASTRUCTURE, RURAL MARKETS, AND SOCIAL DEVELOPMENT

Infrastructure shapes the development of the rural economy largely through its impact on the operation of various markets. It also influences formation of human capital through its impact on the provision of health and education services. Therefore, this chapter compares the operation of various markets and the health and literacy of residents in the developed and underdeveloped villages. A detailed analysis of the operation of the labor market was provided in Chapter 5, whereas the product, land, and credit markets are treated here. However, a comprehensive treatment of product markets, particularly testing for market integration, is not possible with cross-section data for only one period. Therefore, the analysis of the product market is limited to selected aspects of the paddy market and commercialization.

## Spatial and Seasonal Variation in Prices

During the implementation of the survey in 1982, investigators were asked to keep records of the prices of basic necessities prevailing in the local markets in the second and fourth week of each month. For 15 out of the 16 villages under survey, there are 24 observations on prices for each commodity. In one village, Gobindapur, there is no primary market in the locality. Villagers walk five miles to a secondary market located in the *upazila* center, Kaliakoir, carrying goods on head loads (dry season) or in boats (rainy season). The prices quoted for the village are for the secondary market. Ideally, estimates should have been adjusted for the cost of transport and time forgone to obtain the true village prices. These are difficult to estimate, however, without knowing details about the mode of transport for each transaction. Also, the opportunity cost of time would vary from person to person. For other villages, true household-level prices might differ from those quoted depending on the distance of the villages from the place of trade and the mode of transportation used.

Paddy and rice are the major agricultural commodities traded in local markets. Rice accounts for nearly 60 percent of total food consumption in rural areas; nearly 40 percent of the paddy output is marketed. Rice is available in local markets throughout the year, trade is heavy, and the market is competitive. Households sell paddy, often in bulk, which is processed in mills, mostly located in secondary markets. Rice is brought back to local markets for sale to the landless who buy in small quantities throughout the year and to deficit farmers who usually buy before the harvest. The paddy market is a producer market with a high seasonality in sales, while the rice market is a consumer market with less pronounced seasonal variation. For own consumption of farm production, paddy is usually processed by the housewife, even in middle-income households, using the wooden husker *(dhenki),* while the rice purchased from the market is mostly mill processed. With development of infrastructure and access to the rice mills in nearby secondary markets, more paddy is processed by mills, even for household consumption. It is estimated in this survey that 47 percent of the rice consumed by sample households is processed in mills—36 percent in underdeveloped villages and 61 percent in developed villages (Appendix Table 82). Thus, infrastructure increases the demand for paddy processing in mills and expands the volume of trade.

The unweighted average prices of paddy and rice for the year of survey (1982) and for the postharvest period when transactions are heavy are reported in Table 46. The spatial variation in average prices is low, with the coefficient of variation across the 16 locations estimated at only 5 percent for both paddy and rice. The difference between the highest and the lowest prices is about 17 percent. The prices are, in general, lower in underdeveloped villages, but the variation is not systematically related to the index of infrastructure. In developed villages the average price is about 2.4 percent higher for paddy and 5.7 percent higher for rice than in the underdeveloped villages. The seasonal variation in the villages of a developed area (Comilla) is compared with the variation in an underdeveloped area (Jessore) in Figure 5.

Farm households generally sell the major portion of their paddy after harvest and buy back rice before harvest. The variation in postharvest prices of paddy across locations is larger than that in yearly average prices. The difference between the lowest and the highest price is about 33 percent; the coefficient of variation across villages is 8 percent—5 percent for developed villages and 9 percent for underdeveloped villages. Postharvest prices are very low in villages that produce most of the crop in a single season: in Khulna, where most of the land is cropped during the aman season, and in Kushtia and Jessore where most of the crops are produced during the aus season. Within the same agroclimatic regions, prices are significantly higher in the developed

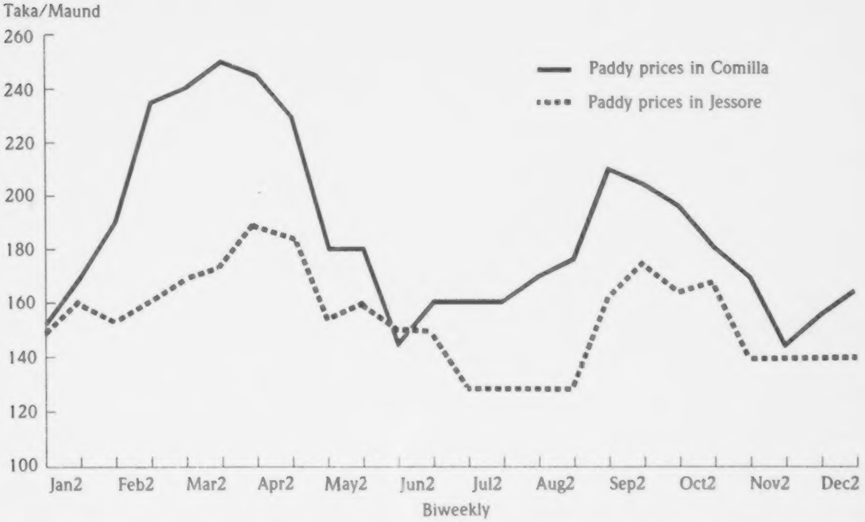
**Table 46—Spatial variation in paddy and rice prices in local markets, 1982**

| Village | District | Infrastructure Underdevelopment Index | Paddy Prices[a] Annual Average | Paddy Prices[a] Post-Harvest Period | Rice Prices[a] Annual Average | Rice Prices[a] Pre-Harvest Period |
|---|---|---|---|---|---|---|
| | | | (Tk/maund) | | (Tk/maund) | |
| Developed | | | 171 | 146 | 296 | 314 |
| Chashapara | Comilla | 1.9 | 186 | 158 | 302 | 320 |
| Bandabeel | Kushtia | 2.9 | 163 | 140 | 279 | 298 |
| Illashpur | Comilla | 3.9 | 189 | 154 | 304 | 320 |
| Patgari | Pabna | 4.5 | 164 | 150 | 312 | 339 |
| Roakuli | Kushtia | 4.7 | 169 | 134 | 259 | 293 |
| Raotara | Pabna | 4.7 | 162 | 141 | 310 | 342 |
| Khejurdanga | Khulna | 5.4 | 162 | 148 | 303 | 288 |
| Underdeveloped | | | 167 | 137 | 280 | 320 |
| Charkhamar | Dhaka | 6.5 | 164 | 139 | 281 | 320 |
| Khunta | Comilla | 7.7 | 175 | 158 | 292 | 323 |
| Rajarampur | Dhaka | 9.5 | 165 | 148 | 286 | 325 |
| Taliamara | Khulna | 9.9 | 171 | 126 | 287 | 327 |
| Harispur | Jessore | 10.1 | 159 | 136 | 265 | 289 |
| Gobrapara | Jessore | 10.2 | 158 | 129 | 273 | 303 |
| Birhat | Khulna | 10.2 | 170 | 118 | 280 | 326 |
| Syedpur | Dhaka | 10.7 | 168 | 136 | 270 | 333 |
| Gobindapur | Dhaka | 13.7 | 170 | 146 | 286 | 334 |
| Unweighted average | | . . . | 168 | 141 | 287 | 318 |
| Coefficient of variation (percent) | | . . . | 5.0 | 7.8 | 5.4 | 5.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] The figures are unweighted averages of the observed prices in village markets. Actual prices received and paid by farmers depend on the proportion of rates and purchases at different times.

**Figure 5—Prices of paddy in underdeveloped villages (Jessore) and developed villages (Comilla)**



Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

villages (compare Khejurdanga with Birhat and Taliamara, Bandabeel and Roakuli with Harispur and Gobrapara).

Although the yearly average price of rice was lower in the underdeveloped villages, the price was higher during the preharvest period when farmers purchase rice from the market. The seasonal variation in rice prices was lower in the developed villages. The ratio between the preharvest and the yearly average prices is 1.06 for developed villages compared with 1.14 for the underdeveloped villages. The seasonal variation in paddy prices was larger than that for rice prices and higher in underdeveloped villages than in developed ones.

The ratio between the annual average prices of rice and paddy is 1.71, while the physical conversion ratio between them is 1.50.[2] This implies a 14 percent margin for processing, trade, and transport. The comparison between the postharvest price of paddy and the preharvest price of rice, however, indicates substantially higher margins. The rice-paddy price ratio for 16 villages for these periods was 2.26, indicating a margin of about 50 percent. For underdeveloped villages this margin is about 56 percent compared with 35 percent for developed villages.

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[2] This is also found to be the pattern for the country as a whole. During 1982 the average wholesale price of aman paddy was Tk 165 and that of aman rice Tk 280 per maund. The price spread was 70 percent, implying a margin of 13 percent (Bangladesh Department of Agriculture and Marketing 1986).

## The Market as a Food Supply Source

In the survey, information was collected on the consumption of basic necessities and their sources of supply on a weekly basis for eight weeks. Annual consumption of the major food items during the survey year and the proportion obtained from the market are reported in Table 47. The data clearly show the high importance placed on subsistence crops in agricultural production. Only one-third of the major food item, rice, is obtained from the market; two-thirds of the rice consumed is obtained from household production. Even for livestock and fishery products and processed food items like *gur* (raw sugar), nearly two-fifths of consumption is met by household production. Only for tuber production, which is concentrated in certain regions, and wheat, for which imports from abroad account for nearly half of domestic supply, do consumers rely upon the market for the major portion of the food consumed. Domestic production of wheat is highly concentrated in the northwestern and western districts of the country, and the government moves a large proportion of imported wheat to interior areas of Bangladesh for implementation of rural public works programs.

Development of infrastructure, however, increases the importance of the market as a source of food. For tubers, which are highly perishable, the amount purchased by an average household is about 77 percent higher in developed villages than in underdeveloped ones. Households in developed villages also purchase significantly larger shares of meat, vegetables, and rice. For pulses, *gur,* and fish, the amount purchased is almost the same in the two groups of villages. The amount of fish and *gur* consumed may have been lower in developed villages because meat was substituted for fish and sugar for *gur*—and hence the amount purchased may have been reduced. The supply purchased from the market as a proportion of the amount consumed was higher in developed villages for all major food items except pulses and wheat.

## Marketing Rates for Paddy

According to detailed information on marketing of paddy collected from farmers, 83 percent of the farmers sold paddy during the year, and 72 percent sold some within two weeks after the harvest (Table 48). Thus the market participation is widespread. About 40 percent of the produce is marketed during the course of a year and 11 percent is marketed within two weeks after the harvest. Comparison of marketing behavior in the two groups of villages indicates that the development of infrastructure has a positive effect on marketing. Farmers marketed 47 percent of the paddy production in developed villages, compared with 35 percent in underdeveloped villages. The proportion marketed immediately after harvest is about twice as high in the developed as in the underdeveloped villages.

Table 48 also compares the prices received by farmers in the two groups of villages, weighted by the proportion of sales; hence they are different from the unweighted average prices prevailing in local markets at different points of time, as reported in Table 46. Although farmers received higher prices in developed areas, the difference was only 3.5 percent. For immediate postharvest sales, the price was higher in developed areas by 7.7 percent.

The findings of the survey on the marketing of paddy for different landholding groups are reported in Table 49. Market participation and the proportion of output marketed are highly positively related only to the size of land in underdeveloped villages. Almost all farmers owning more than 2.0 acres of land participated in the market, compared with 65 percent of farmers owning less than 2.0 acres. Farmers owning

### Table 47—Share of major foods purchased from markets, 1982

| Food Item | Market Supply as a Percent of Consumption | |
|---|---|---|
| | Developed Villages | Underdeveloped Villages |
| | (percent) | |
| Rice | 34 | 29 |
| Mill processed | 38 | 37 |
| *Dhenki* processed[a] | 26 | 24 |
| Wheat | 84 | 85 |
| Tubers | 92 | 77 |
| Vegetables | 60 | 46 |
| Pulses | 55 | 63 |
| Fish | 62 | 57 |
| Meat | 57 | 53 |
| *Gur* (raw sugar) | 68 | 56 |
| Total | 49 | 44 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Processed at home using a wooden husker.

more than 5.0 acres marketed about one-half of their production, compared with about one-fifth of small farmers' production. The large farmers' share was 45 percent of the total amount marketed in these villages, whereas they composed only 12 percent of the rural households and about 33 percent of the output. Consequently, price incentive policies would benefit large farmers proportionately more than smaller ones.

The situation was different in the developed villages, where a much larger proportion of the marginal and small farmers sold paddy in the market, and the proportion of output marketed was *not* systematically related to the size of landholding. On the basis of this evidence, it can be concluded that infrastructure development leads to a greater

### Table 48—Marketing of paddy by farm households, developed and underdeveloped villages, 1982

| Variables | Developed Villages | Underdeveloped Villages | All Villages |
|---|---|---|---|
| Production of paddy (kilograms/farm household) | 2,608 | 2,555 | 2,578 |
| Sales of paddy (kilograms/farm household) | 1,213 | 890 | 1,026 |
| Percent of farm households that sold paddy | 88 | 80 | 83 |
| Sales within two weeks after harvest (kilograms/farm household) | 261 | 206 | 274 |
| Percent of farm households that sold paddy within two weeks | 72 | 73 | 72 |
| Percent of total paddy output marketed | 47 | 35 | 40 |
| Percent of total paddy output marketed within two weeks | 14 | 8 | 11 |
| Price received (Tk/maund) | 150 | 145 | 148 |
| Price received immediately after harvest (Tk) | 153 | 142 | 148 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

## Table 49—Marketing of paddy by size of landholding, 1982

| Size of Farm | Percent of Farmers Marketing Paddy | Percent of Paddy Marketed | Share of the Group in Marketing | Within Two Weeks After Harvest: Percent of Farmers Marketing Paddy | Within Two Weeks After Harvest: Percent of Paddy Marketed |
|---|---|---|---|---|---|
| (acres) | | | (percent) | | |
| Underdeveloped | | | | | |
| Landless | 46 | 14 | 3 | 34 | 3 |
| Land owned | | | | | |
| Small | 74 | 21 | 13 | 64 | 8 |
| Medium | 91 | 36 | 39 | 86 | 9 |
| Large | 100 | 47 | 45 | 100 | 9 |
| Developed | | | | | |
| Landless | 92 | 52 | 7 | 72 | 13 |
| Land owned | | | | | |
| Small | 81 | 44 | 27 | 66 | 12 |
| Medium | 92 | 43 | 34 | 76 | 14 |
| Large | 100 | 53 | 32 | 75 | 15 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

degree of commercialization among farmers, including small producers. In developed villages, one-third of the market supply came from the marginal and small farmers; in the underdeveloped villages, their share was one-sixth.

In order to test the statistical significance of the effect of infrastructure on marketing of paddy, the following regression equation is estimated from the farm-level data:

$$\begin{array}{l} \mathrm{MRKT} = 46.9 + 0.14\,\mathrm{PDDQ} - 0.85\,\mathrm{FSZ} - 0.04\,\mathrm{PRC} - 2.68\,\mathrm{INF}; \\ \qquad\qquad\qquad (3.79) \qquad\quad (-1.48) \qquad (-0.19) \qquad (-3.55) \end{array}$$

Log-L = 288, N = 455,

where

MRKT = the percent of output marketed by the farmer,
PDDQ = the output of paddy,
FSZ = the number of consumers in the household,
PRC = the village-level price of paddy, and
INF = the index of underdevelopment of infrastructure.

Figures in parentheses are estimated t-values. The hypothesis is that the proportion marketed will increase with the size of output and decrease with the size of the household, since a larger amount would be retained for household consumption. The equation is estimated using the Tobit method since several cases have zero observations for the dependent variable. After controlling for the effect of other variables, the coefficient of infrastructure is found to be highly statistically significant. The negative sign of the coefficient indicates that, given the level of output and family size, the more underdeveloped the village, the lower the proportion of paddy marketed. Appendix

Table 83 demonstrates similar results using the amount of paddy marketed as the dependent variable.

The regression coefficient of price in the above equation indicates that the price does not have any effect on marketing. This is presumably because infrastructure works partly through prices and partly by allowing farmers easy access to traders. This is supported by the following equation estimated only for farmers in developed villages:

$$\text{MRKT} = \underset{(1.55)}{29.7} + \underset{(1.67)}{0.083}\,\text{PDDQ} - \underset{(-1.52)}{1.27}\,\text{FSZ} + \underset{(1.95)}{2.30}\,\text{PRC} - \underset{(-1.50)}{5.99}\,\text{INF};$$

$\text{Log-L} = -106, \quad N = 195.$

The price coefficient is positive, indicating that a larger proportion of output is marketed at higher prices, and it is statistically significant at the 5 percent level. The price elasticity of market supply is estimated to be 0.3. The infrastructure coefficient has the correct sign, but the estimated t-value is now weakly significant at the 13 percent level.

For underdeveloped villages, the estimated equation is

$$\text{MRKT} = \underset{(2.16)}{94.7} + \underset{(2.22)}{0.130}\,\text{PDDQ} + \underset{(0.22)}{0.23}\,\text{FSZ} - \underset{(-0.72)}{0.18}\,\text{PRC} - \underset{(-3.40)}{5.74}\,\text{INF};$$

$\text{Log-L} = -166, \quad N = 260.$

Household sizes and prices in these villages had no effect on the marketing ratio, but the size of output and the state of development of infrastructure were highly significantly related to marketing.

## The Land Market

Land is an important asset for most rural households. For those who own land, it is a source of regular income, a security against famine, and the foundation for a dependable livelihood for future family generations. Therefore, the traditional value system puts a high premium on ownership of land. How the land market in rural Bangladesh evolves as infrastructure development progresses is therefore an interesting question.

An aggregate analysis of land prices shows the effect of land productivity and infrastructure development on land prices. However, it does not reveal much about the nature of underlying markets in operation at the village level. This is partly attempted through the sample data. Unfortunately, the sample was not specifically designed for studying land markets and therefore is deficient in a number of land market aspects.

Who buys and sells land in rural areas? A number of conclusions can be derived from the statistics in Table 50. First, in terms of the number of households participating in the land market, the market appears to be tighter in developed villages than in underdeveloped. Only 8.0 percent of all households in developed villages are land buyers and 4.3 percent are land sellers. That there are more buyers than sellers in developed villages possibly indicates transactions with outside sellers. The proportions of buyers and sellers in underdeveloped villages are exactly the same, indicating that all transactions are probably within the group. Second, in rural areas transactions largely involve functionally landless and small farmers as the sellers and medium and large

## Table 50—Proportion of total households buying and selling land, 1982

| Land Market Participant | Land Owned | | | | |
|---|---|---|---|---|---|
| | Landless | Small | Medium | Large | All |
| | | | (percent) | | |
| Developed villages | | | | | |
| Buyers | | | | | |
| Share of all households | 1.1 | 5.9 | 12.1 | 33.3 | 8.0 |
| Share of buying households | 4.5 | 27.3 | 36.4 | 31.8 | 100.0[a] |
| Sellers | | | | | |
| Share of all households | 8.0 | 4.0 | 1.5 | 0.0 | 4.3 |
| Share of selling households | 58.3 | 33.3 | 8.3 | 0.0 | 99.9[a] |
| Underdeveloped villages | | | | | |
| Buyers | | | | | |
| Share of all households | 4.8 | 7.0 | 16.5 | 19.5 | 10.4 |
| Share of buying households | 13.5 | 21.6 | 43.2 | 21.6 | 99.9[a] |
| Sellers | | | | | |
| Share of all households | 8.6 | 14.0 | 7.2 | 12.2 | 10.4 |
| Share of selling households | 24.3 | 43.2 | 18.9 | 14.3 | 100.7 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Numbers may not total 100 because of rounding.

owners as the buyers. This general pattern is even clearer for developed villages than for underdeveloped ones. In developed villages, about 70 percent of those who bought land were large and medium landowners and the remaining 30 percent were functionally landless or small landowners. Of all households selling land, about 82 percent were landless and small owners and the remaining 18 percent were medium-size landowners. The pattern was similar but less extreme in underdeveloped villages, where about 65 percent of land-buying households were large and medium landowners and 35 percent landless and small landowners. Among the total land-selling households, the proportion of large and medium owners was 32 percent and the proportion of landless and small owners was 68 percent.

However, the number of buyers and sellers in the market does not explain the market density in terms of the amount of land transacted (see Table 51). The overall picture that emerges from this table indicates that less than 2 percent of the total land owned is bought and sold in a year in village land markets. But the distribution among the landholding groups of the land transactions differs between developed and underdeveloped villages.

In developed villages only 0.7 percent of the land area owned by all households is sold, while 1.6 percent of the total land owned is purchased. This indicates that owners from outside developed villages sell land to households in developed villages. This difference is negligible in underdeveloped villages. In developed villages, about 97 percent of land sold is sold by small and functionally landless households, whereas in underdeveloped villages the share of small and landless households in the total land area sold is 47 percent. Similarly, the share of large and medium owners in the total land purchased is 79 percent in developed villages, compared with 77 percent in underdeveloped villages.

The general conclusion is that the land market in rural areas is very thin, particularly in terms of the amount of land transacted. Infrastructure development further reduces the size of the market, even though it tends to widen the geographic boundaries within which the buyers and sellers operate. Generally, small landowners are the sellers and

**Table 51—Shares of land area bought and sold, developed and underdeveloped villages, 1982**

| Landownership Group | Share of Land Area Purchased: In Total Land Owned | Share of Land Area Purchased: In Total Land Purchased | Share of Land Area Sold: In Total Land Owned | Share of Land Area Sold: In Total Land Sold |
|---|---|---|---|---|
| | | (percent) | | |
| Underdeveloped villages | | | | |
| Landless | 3.3 | 4.5 | 8.4 | 12.9 |
| Land owned | | | | |
| Small | 1.8 | 18.9 | 2.9 | 33.9 |
| Medium | 1.5 | 39.5 | 1.1 | 33.2 |
| Large | 1.2 | 37.1 | 0.6 | 20.0 |
| All households | 1.5 | 100.0 | 1.3 | 100.0 |
| Developed villages | | | | |
| Landless | 0.8 | 1.2 | 12.8 | 45.9 |
| Small | 1.4 | 20.2 | 1.5 | 50.9 |
| Medium | 0.7 | 17.5 | 0.1 | 3.2 |
| Large | 3.0 | 61.1 | 0.0 | 0.0 |
| All households | 1.6 | 100.0 | 0.7 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

large landowners are the buyers, a dichotomy that sharpens with infrastructure development.

These two important factors concerning land markets—the thinness of the market and the dichotomy between buyers and sellers—seem to affect land prices. Land is also valued as income security for future generations, and both these factors reflect that. Consequently, no one wants to sell land unless under distress. Any development that improves the income-earning capacity of the poor will therefore reduce the supply of land, and infrastructure development (as is shown in the chapter on income) is such a factor. At the same time, the increased income of the richer households places upward pressure on demand. This divergence of demand and supply arising from rural development leads to an extremely sharp increase in land prices.

## The Credit Market

The credit market is an important area of rural development. Understanding of the structure and conduct of this market, however, is vague. Early work on rural informal credit markets portrayed them as monopolistic and therefore exploitative (Rudra 1982). Virmani (1982) postulated that the equilibrium interest rate is a function of the opportunity cost of the funds to the lender, the transaction costs, the probability of default, and the amount of collateral. Following this formulation, it can be argued that the information cost for assessing the probability of default and the transaction costs are high in informal credit markets, which justifies high interest rates. That rural credit markets are fragmented seems to be widely accepted, although it is not clear how competition equates the cost of credit with the interest rate in fragmented markets, when such markets should have monopolistic conditions.

These concepts of rural credit markets have far-reaching implications. If the credit market is monopolistic and exploitative, then introduction of institutional credit is likely to reduce the interest rate in informal markets, although, where excess demand for credit abounds, institutional credit will not substitute for moneylenders. If the credit market is so competitive that the interest rate in the market is equal to the cost of credit, then expansion of institutional credit may result in the contraction of informal credit without much change in the total volume (formal plus informal) of credit transactions.

It would have been ideal to examine the impact of infrastructure development on rural credit markets in the context of these issues, but the data available do not permit such a dynamic inquiry. What is presented below is a snapshot of the rural credit market, unraveling its structural facets in a comparative context of infrastructurally developed and underdeveloped situations and enabling some qualitative deductions to be made on the workings of rural credit markets and the influence of infrastructure development on these markets.

### Aggregate Size

It should be noted that the aggregate size of the rural credit market given in Table 52 does not represent the total demand; it reflects the volume of total transactions, cleared through various credit rationing mechanisms, which could be much smaller than the total demand. Institutional sources provide 25 percent and noninstitutional sources 75 percent of the total credit supplied and received in rural areas. About 14 percent of all rural households borrow from institutional sources and 70 percent from noninstitutional.

Thus, the informal credit market is still the dominant source of rural credit, and participation of rural households in this market is widespread. Institutional credit accounts for only one-fourth of the total transactions in rural credit and involves only a small fraction of rural households. The average credit per borrowing household is Tk 2,254 for institutional credit and Tk 1,382 for noninstitutional credit; the weighted average of the two sources is Tk 1,600 (Tk 22.85 equaled US$1.00 in 1982). This is equivalent to about 58 percent of the average gross savings and investment per rural household estimated in Chapter 8. The average institutional credit for all borrowing and nonborrowing households is Tk 323 per household. This figure is multiplied by 12.5 million, the total number of estimated rural households in 1982, in order to obtain the national aggregate, which is estimated at Tk 4,038 million and comes close to the estimate of Tk 4,238 million based on information from the sources of supply (Hossain 1987). The difference between the two estimates is only about 5 percent. This sample may thus be considered quite representative of the national picture.

### Institutional Credit and Infrastructure

Institutional credit is normally supplied through banks and cooperatives, but occasionally through specialized government departments created to handle special projects or commodity development programs. Whereas banks are usually located in areas with relatively developed infrastructure, cooperatives are widespread throughout rural areas of Bangladesh, regardless of the state of the area's infrastructure, because the government is pursuing a policy of universal coverage. This does not mean, however, that all such cooperatives are functionally effective in all locations. Among the rural financial institutions, only commercial banks accept deposits and advance loans; other financial institutions, including specialized government banks for agriculture such as the Krishi Bank, only advance loans with no facilities for savings deposits. During the years from 1980 through 1983, the average annual bank deposit in rural areas was about 11 percent larger than the average annual loan advance from these rural banks (Bangladesh Bureau of Statistics 1985b). If the Krishi Bank is excluded from this calculation, then deposits in commercial banks are about 65 percent larger than their loan advances.

### Table 52—Size of the rural credit market in the sample villages, 1982

| Item | Credit from Institutional Sources | Credit from Noninstitutional Sources |
|---|---|---|
| Amount of total credit (Tk) | 202,826 | 605,552 |
| Number of borrowing households | 90 | 438 |
| Average credit per borrowing household (Tk) | 2,254 | 1,382 |
| Average credit over all households[a] (Tk) | 323 | 964 |
| Proportion of borrowing households[b] (percent) | 14.3 | 69.7 |
| Shares of total credit (percent) | 25.0 | 75.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] All households includes those that did not borrow.

[b] This is the proportion of borrowing households in the total of 628 households in the sample.

Thus, rural commercial banks can be considered largely a mechanism for transferring financial resources from rural to urban areas, whereas other institutions such as cooperatives and the Krishi Bank pump financial resources into the rural economy.

Data from the 16 villages show that the proportion of households receiving institutional credit is slightly higher in infrastructurally developed than in underdeveloped areas (Table 53), but the difference is not significant (15.1 percent compared with 13.7 percent). However, no institutional credit at all was received in 6 villages, 5 of which are in underdeveloped areas. Of the 10 villages receiving credit, 4 accounted for 76 percent. Two of the 4 villages were in infrastructurally developed areas and the other 2 in underdeveloped areas, one of which has a historical background of educational advancement. Interest in education in this relatively progressive Hindu community was nurtured during the British raj, and the value of educational progress has had a lasting impression on contemporary households in that village. Their advancement in education appears to have enabled the households to obtain better access to institutional credit, overcoming the constraint of infrastructural backwardness. Such historical advantage is incidental. If this village is excluded, the proportion of households receiving institutional credit is found to be only 3.6 percent in underdeveloped areas, compared with 15.1 percent in developed areas. The other village that is located in an infrastructurally backward area has access to institutional credit because it is part of the Comilla Cooperative Development scheme. If that village is also excluded, then virtually no household in an infrastructurally underdeveloped village received institutional credit. The lesson is that special efforts in educational and cooperative development, even if costly, can enhance access to institutional credit for households in infrastructurally underdeveloped areas. But even without special government effort, infrastructure development makes an impressive difference in access to institutional credit.

A few more findings in Table 53 deserve to be highlighted. The table shows that functionally landless households have relatively poor access to institutional credit, which is not surprising. What is striking, however, is the extent to which small farmers in developed villages receive institutional credit compared with small farmers in underdeveloped areas, both in the number of households receiving credit and in shares of total credit. The contribution of developed infrastructure to the improvement of access of small farmers to institutional credit is significant. Although the average credit received per household in developed areas is 3.3 percent smaller than that received in underdeveloped areas, the size of land owned per household is about 34 percent smaller in

## Table 53—Receipt of credit from institutional sources by landownership and infrastructure groups, sample of 16 villages, 1982

| Landownership Group | Developed Villages (Seven) | | | | Underdeveloped Villages (Three) | | | |
|---|---|---|---|---|---|---|---|---|
| | Average Credit/ Household | Number of Households Receiving Credit | Share of Households Receiving Credit | Share of Total Credit | Average Credit/ Household | Number of Households Receiving Credit | Share of Households Receiving Credit | Share of Total Credit |
| | (Tk) | | (percent) | | (Tk) | | (percent) | |
| Landless | 1,233 | 3 | 3.5 | 4.1 | 1,173 | 10 | 9.5 | 10.5 |
| Land owned | | | | | | | | |
| Small | 1,781 | 18 | 18.2 | 35.3 | 1,154 | 14 | 12.3 | 14.4 |
| Medium | 2,466 | 14 | 21.4 | 38.0 | 2,617 | 18 | 18.6 | 42.0 |
| Large | 3,412 | 6 | 28.6 | 22.6 | 5,301 | 7 | 17.1 | 33.1 |
| All | 2,213 | 41 | 15.1 | 100.0 | 2,287 | 49 | 13.7 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.
Note: Six of the 16 sample villages received no institutional credit.

developed than underdeveloped areas. Thus, institutional credit per acre of owned land is about 29 percent larger in developed than underdeveloped areas.

### Noninstitutional Credit and Infrastructure

Noninstitutional credit involves lending and borrowing among local households. Generally friends and relatives or village moneylenders, including landowners to sharecroppers, lend money in the informal credit market. Money lending is not the primary occupation of village moneylenders. Generally, well-to-do farmers and businessmen operate in this market to obtain an additional source of income. Lending is both in cash and in kind (Table 54). Fifteen to 20 percent of the total credit from noninstitutional sources is received in kind and the rest in cash. Credit in kind represents borrowing, primarily of paddy for consumption and seeds, that has to be repaid, usually in kind but occasionally in cash. About 62 percent of households borrow cash; the difference between developed and underdeveloped areas is not significant in this respect. About 13 percent of households borrow in kind. Therefore, the proportion of households participating in the noninstitutional credit market is large.

Landless and small landowners constitute most of the borrowers in the noninstitutional credit market. For example, about 84 percent of landless households in developed and 97 percent in underdeveloped villages borrow cash from noninstitutional sources. The comparable figures for large owners is 24 percent in developed and 32 percent in underdeveloped villages. The degree of concentration of borrowers in landless and small landowning households is clearly greater in developed areas—a pattern somewhat the reverse of that observed for institutional credit. This phenomenon may simply reflect a greater demand for credit among landless and small farm households in developed villages, induced by investment opportunities created by infrastructural development. Moreover, limited access of such households to institutional credit, though greater than access in underdeveloped areas, is likely to push these households to informal markets.

It was mentioned earlier that most noninstitutional credit is supplied by friends and relatives or moneylenders. The respective shares of these two broad groups in total supply of noninstitutional credit, shown in Table 55, indicate that large landowning households borrow less frequently from noninstitutional sources, and when they do, they borrow mostly from friends and relatives. Credit from friends and relatives, which is based on mutual confidence and trust, generally bears little or no interest. It is generally a two-way traffic: one may borrow from a friend today but may also lend to him tomorrow.

Table 55 also indicates that the share of moneylenders in total noninstitutional credit is generally larger in infrastructurally developed villages than in underdeveloped. It seems that the growth of mercantile practices is accelerated by infrastructure development, and the process of commercialization expands informal credit markets, as well as product markets.

### Terms of Noninstitutional Credit and Interest Rates

Although the population of Bangladesh is largely Moslem, and Islamic law prohibits payment or earning of interest, this religious stricture is not supported by the legal system of the country. Usually, rural noninstitutional credit sources do not charge any direct interest. Often, a loan agreement stipulates that X amount of money or quantity of a commodity borrowed has to be repaid in $(X + Y)$ amount of money or quantity of a commodity after n number of months. The implicit annual interest rate is of course $(Y/X) \times (12/n) \times 100$. Where land is mortgaged to the lender as collateral for a loan,

## Table 54—Receipt of credit in cash and in kind from noninstitutional sources, 1982

| Landownership Group | Developed Villages |  |  |  | Underdeveloped Villages |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Average Credit/ Household | Number of Households Receiving Credit | Share of Households Receiving Credit | Share of Total Credit | Average Credit/ Household | Number of Households Receiving Credit | Share of Households Receiving Credit | Share of Total Credit |
|  | (Tk) |  | (percent) |  | (Tk) |  | (percent) |  |
| Credit in cash |  |  |  |  |  |  |  |  |
| Landless | 1,215 | 72 | 83.7 | 36.5 | 772 | 102 | 97.1 | 23.1 |
| Land owned |  |  |  |  |  |  |  |  |
| Small | 1,391 | 63 | 63.6 | 36.6 | 1,511 | 56 | 49.1 | 24.8 |
| Medium | 1,767 | 30 | 46.2 | 22.1 | 2,132 | 46 | 47.4 | 28.8 |
| Large | 2,280 | 5 | 23.8 | 4.8 | 6,111 | 13 | 31.7 | 23.3 |
| All | 1,409 | 170 | 62.7 | 100.0 | 1,571 | 217 | 60.8 | 100.0 |
| Credit in kind |  |  |  |  |  |  |  |  |
| Landless | 356 | 20 | 23.2 | 48.9 | 236 | 19 | 18.1 | 42.5 |
| Land owned |  |  |  |  |  |  |  |  |
| Small | 354 | 13 | 13.1 | 31.6 | 203 | 11 | 9.6 | 21.2 |
| Medium | 345 | 6 | 9.2 | 14.2 | 410 | 7 | 7.2 | 27.2 |
| Large | 750 | 1 | 4.8 | 5.2 | 960 | 1 | 2.4 | 9.1 |
| All | 364 | 40 | 14.7 | 100.0 | 278 | 38 | 10.6 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 55—Distribution of noninstitutional credit by source of supply and landownership group, 1982

| | Developed Villages | | Underdeveloped Villages | |
|---|---|---|---|---|
| Landownership Group | Credit from Friends and Relatives[a] | Credit from Moneylenders | Credit from Friends and Relatives[a] | Credit from Moneyenders |
| | | (percent) | | |
| Landless | 31.5 | 68.5 | 31.3 | 68.7 |
| Land owned | | | | |
| Small | 44.3 | 55.7 | 48.2 | 51.8 |
| Medium | 39.2 | 60.8 | 47.7 | 52.3 |
| Large | 86.8 | 13.2 | 82.9 | 17.1 |
| All | 38.9 | 61.1 | 49.0 | 51.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

[a] Borrowing from landowners by sharecroppers is included in this category.

the lender often cultivates that land until the borrower refunds the credit, subject to a minimum time of one year. In such cases the implicit interest rate is the profit for the year (taking account of multiple cropping) from crops harvested on this land. In all other cases in the data set, where no land mortgage was involved, the credit term ranged from 4 to 7 months; the average was 4.6 months.

Keeping these terms in view, estimates of implicit interest rates on noninstitutional credit in Table 56 show that households pay an extremely high rate of interest on noninstitutional credit. The mean annual rate of interest is 125 percent in developed villages and 109 percent in underdeveloped villages. For landless households, the interest rate is higher than these averages by about 27 percent in developed villages and 14 percent in underdeveloped. In developed villages the interest rate declines for large landowners, but this pattern does not hold in underdeveloped villages. However,

## Table 56—Interest rates for noninstitutional credit, by landownership group, 1982

| | Developed Villages | | | Underdeveloped Villages | | |
|---|---|---|---|---|---|---|
| Landownership Group | Mean Interest Rate | Standard Deviation | Coefficient of Variation[a] | Mean Interest Rate | Standard Deviation | Coefficient of Variation[a] |
| | | | (annual percentage rate) | | | |
| Landless | 158.6 | 195.0 | 1.23 | 124.3 | 65.3 | 0.53 |
| Land owned | | | | | | |
| Small | 108.5 | 72.3 | 0.67 | 83.6 | 148.6 | 1.78 |
| Medium | 115.3 | 140.5 | 1.22 | 112.2 | 83.3 | 0.74 |
| Large | 58.4 | 68.9 | 1.18 | 113.6 | 102.3 | 0.90 |
| All | 124.6 | 137.6 | 1.10 | 109.1 | 102.6 | 0.94 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

[a] The coefficient of variation is measured by dividing the standard deviation by the mean.

the variability of interest rates (as indicated by the standard deviation) even within a landownership group is so high that any generalization is rather risky. This no doubt reflects the varied nature of the rural informal credit market, a market that is so fragmented that almost every loan is a specific market.

In Table 57, where loan cases are broken down by the amount of interest paid, it can be seen that about 50 percent of the loans in the underdeveloped area and 32 percent of the loans in the developed area bear no interest rates. These cases of no interest charged mostly represent lending and borrowing between friends and relatives. However, not all such loans are interest free. The bulk of the loans with positive interest rates bear a rate higher than 50 percent.

Because interest-free loans in the total number of noninstitutional cases are extensive, it is natural to enquire whether such practices are limited to a certain category of households. The practice primarily occurs between friends and relatives, but is there any difference in the incidence of this practice between households with different land endowments? About 75 percent of all interest-free loans in underdeveloped villages, accounting for about 94 percent of the total volume of such credit, are limited to households classified as medium and large landowners (Table 58). In infrastructurally developed villages, these groups account for about 55 percent of all interest-free loans, and about 78 percent of the total volume. Therefore, it seems likely that interest-free loan transactions are largely a credit mechanism used by relatively rich rural households. Infrastructure development appears to reduce the incidence and the extent of interest-free credit practices.

### Interest Rates in Institutional Credit Markets

Institutional credit markets are controlled by the government directly or indirectly; therefore, interest rates are likely to be more uniform in this market. However, the interest rates charged by banks are generally lower than those for credit from cooperatives. Moreover, cooperatives might legally or illegally charge varying rates to various households depending on the type of cooperative and its management structure. As a

### Table 57—Distribution of noninstitutional loan cases by class of interest rate, in developed and underdeveloped villages, 1982

| Annual Interest Rate | Developed Villages |  | Underdeveloped Villages |  |
|---|---|---|---|---|
|  | Number of Cases[a] | Percent of Interest-Bearing Cases | Number of Cases[a] | Percent of Interest-Bearing Cases |
| (percent) |  |  |  |  |
| No interest | 77 | . . . | 188 | . . . |
| Interest rate charged |  |  |  |  |
| Up to 13 | 7 | 3.5 | 2 | 1.2 |
| 14–24 | 6 | 3.1 | 4 | 2.1 |
| 24–49 | 16 | 10.0 | 11 | 5.5 |
| 50–99 | 31 | 19.4 | 54 | 27.1 |
| 100–149 | 56 | 35.0 | 75 | 37.7 |
| 150–200 | 50 | 31.3 | 48 | 24.1 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] The number of cases is not equivalent to the number of households because a household may have taken more than one loan.

### Table 58—Distribution of interest-free noninstitutional credit by landownership groups, 1982

| Landownership Group | Developed Villages |  | Underdeveloped Villages |  |
|---|---|---|---|---|
|  | Proportion of Interest-Free Loan Cases | Share in Total Interest-Free Credit | Proportion of Interest-Free Loan Cases | Share in Total Interest-Free Credit |
|  | (percent) |  |  |  |
| Landless | 20.2 | 6.5 | 12.9 | 1.9 |
| Land owned |  |  |  |  |
| Small | 25.1 | 15.4 | 12.9 | 3.9 |
| Medium | 23.8 | 19.2 | 18.9 | 10.1 |
| Large | 30.9 | 58.9 | 55.3 | 84.1 |
| All | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

result, although the institutional interest rate ought not to vary much, it does in practice, at least modestly.

The average interest rate in developed villages is 13.5 percent and that in underdeveloped villages is 15.6 percent (Table 59). The rate in the latter case is thus about 15.6 percent higher. However, even for institutional credit, the relation between interest rates and landownership in underdeveloped villages is inverse, implying that small owners and landless households pay higher rates of interest than relatively large landowners. In developed villages this relationship does not hold, and interest rates are relatively uniform across landownership groups. Moreover, variability in interest rates appears to be significantly higher in small landowning and landless groups than for larger farms in underdeveloped villages, but not in developed villages. Therefore,

### Table 59—Interest rates for credit in institutional markets, by landownership groups, 1982

| Landownership Group | Developed Villages |  |  | Underdeveloped Villages |  |  |
|---|---|---|---|---|---|---|
|  | Mean Interest Rate | Standard Deviation | Coefficient of Variation[a] | Mean Interest Rate | Standard Deviation | Coefficient of Variation[a] |
|  | (percent) |  |  | (percent) |  |  |
| Landless | 12.5 | 4.9 | 0.39 | 24.9 | 18.0 | 0.72 |
| Land owned |  |  |  |  |  |  |
| Small | 12.7 | 5.6 | 0.44 | 16.1 | 10.2 | 0.63 |
| Medium | 16.0 | 6.6 | 0.41 | 13.9 | 1.5 | 0.11 |
| Large | 11.0 | 2.1 | 0.19 | 12.8 | 1.6 | 0.12 |
| Average | 13.5 | 5.1 | 0.38 | 15.6 | 8.7 | 0.56 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

[a] The coefficient of variation is measured by dividing the standard deviation by the mean.

infrastructure development contributes to the reduction in interest costs of institutional credit for small farmers and landless households. At the same time, it brings uniformity in interest rates across various landownership groups.

### Utilization of Institutional Credit

Although the survey did not cover utilization of rural credit in a detailed manner, the information provided gives a partial but insightful picture of the demand side of rural credit (Table 60). To compare the demand side with the supply side, total institutional credit for households is given as Tk 202,826 in Table 52, the supply side, and, from the response on utilization of credit in Table 60, the total estimate of institutional credit of Tk 187,224 represents the demand side. The estimates are remarkably close for sample surveys, the difference between the two being only 8 percent.

Table 60 shows that the largest share of institutional credit goes to supplement the working capital of business and trade in developed villages and for current agricultural inputs in underdeveloped villages. The second largest share is used to finance current inputs in agriculture in developed areas. These two categories together compose 72 percent of institutional credit in developed villages and 50 percent in underdeveloped villages. Roughly 13 percent (12.7 percent in developed and 13.3 percent in underdeveloped villages) is used for fixed agricultural investment (such as machinery and equipment).

Approximately 15 percent of institutional credit in infrastructurally developed villages is allocated to directly nonproductive activities. Consumption, debt payment, and purchase of land are considered nonproductive. These activities in underdeveloped villages add up to about 37 percent of total institutional credit.

The most remarkable result in Table 60 is the difference between developed and underdeveloped villages in the shares of credit used for working capital in business. Households in developed villages allocate a share of credit to business almost four times larger than that of households in underdeveloped villages. This is indicative of the increased opportunities for business and trade brought about by infrastructure development.

Institutional credit for rural households in Bangladesh is largely supplied by public agencies for agricultural purposes—for financing current inputs and durable invest-

**Table 60—Pattern of utilization of institutional credit, 1982**

| Use | Developed Villages | | Underdeveloped Villages | | All Villages | |
|---|---|---|---|---|---|---|
| | Amount | Percent of Total | Amount | Percent of Total | Amount | Percent of Total |
| | (Tk) | | (Tk) | | (Tk) | |
| Consumption | 11,101 | 12.4 | 12,580 | 12.8 | 23,681 | 12.6 |
| Debt payment | 1,500 | 1.7 | 14,200 | 14.5 | 15,700 | 8.4 |
| Land purchase | 1,125 | 1.3 | 9,500 | 9.7 | 10,625 | 5.7 |
| Current input in agriculture | 23,520 | 26.4 | 36,700 | 37.5 | 60,220 | 32.5 |
| Current input/acre | 337 | . . . | 300 | . . . | 305 | . . . |
| Fixed investment in agriculture | 11,300 | 12.7 | 12,998 | 13.3 | 24,298 | 13.0 |
| Working capital for business and industry | 40,700 | 45.6 | 12,000 | 12.2 | 52,700 | 28.1 |
| Total | 89,246 | 100.0 | 97,978 | 100.0 | 187,224 | 100.0 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

ments. The suppliers' objective for credit seems inconsistent with the pattern of needs on the demand side. There is nothing wrong in the use of credit for business and trade instead of agriculture. But recognizing the nature of demand at the household level and designing institutional credit programs to suit that demand could rectify many ill effects of programs, including corruptive practices. Households' efforts to hide their real intentions and pretend that credit will be used for agriculture are often expensive, increasing the transaction costs to borrowers.

## Social Development

### Education

Education is a basic human need. Illiteracy is widespread in Bangladesh and there has been little improvement over time. The 1981 population census estimated literacy rates for the adult population (15 years and over) at 29 percent—48 percent in urban areas and 25 percent in rural areas. For the population over 5 years of age, the literacy rate was estimated at 21 percent for rural areas and 41 percent for urban areas.

Access to educational institutions is treated as an element of infrastructure in this study, but other facets of infrastructure could affect education by interacting with both the supply and the demand sides. The development of transport facilities is a major factor influencing the location of an educational institution, particularly at the secondary level, since students have to be drawn from a number of villages in order to make it viable. When transport facilities are underdeveloped, households in villages located near the school are more likely to send their children to school than those in remote villages. Development of infrastructure increases the scope for employment in nonagricultural activities, some of which may require basic literacy and numeracy. Thus, the demand for education may increase with infrastructure development.

The survey used for this study was *not* conducted for explicit testing of these hypotheses. However, it provides information on the educational status of all members of the sample households, and it is analyzed here to assess the impact of infrastructure on literacy, the outcome of the supply and demand forces mentioned here. To assess the effects of infrastructure, it is necessary to control the effects of a number of important socioeconomic variables that affect literacy.

Data on the distribution of the sample population by years of schooling completed in the two groups of villages supports the national picture of low rates of literacy in the country. Three-fifths of the population never attended school and 11 percent completed only two years—not enough to have a lasting effect on literacy. Thus, only about 29 percent can be considered literate. Of the literates, one-half had only a primary education and only a few went on to the secondary level. Only 2 percent completed 10 years of schooling.

The survey also finds that there are significant differences in the educational status of men and women in Bangladesh, with about 80 percent of women functionally illiterate and 62 percent of men. The difference is not associated with the infrastructure development of the villages.

The development of infrastructure does not seem to have much effect on literacy. The chi-square value for the difference in distribution of education in developed and underdeveloped villages is not statistically significant. However, educational status does vary significantly according to the size of land held by the household (Table 61). In underdeveloped villages, nearly 80 percent of people from landless households never attended school, compared with 63 percent for small landowners and 46 percent from

## Table 61—Educational status of household members by size of landholding, developed and underdeveloped villages, 1982

| Infrastructure Group/ Size of Landholding | Years of Schooling Completed | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1–2 | 3–5 | 6–8 | 9–10 | 11 or More |
| | | | (percent of population) | | | |
| Underdeveloped villages | | | | | | |
| Less than 0.5 acres | 78.7 | 11.0 | 5.9 | 2.7 | 1.7 | . . . |
| 0.5–2.0 acres | 63.0 | 12.6 | 11.7 | 6.7 | 4.2 | 1.6 |
| 2.0 acres or more | 46.1 | 13.0 | 19.4 | 9.9 | 8.4 | 3.4 |
| Total | 58.1 | 12.4 | 14.2 | 7.3 | 5.8 | 2.1 |
| Developed villages | | | | | | |
| Less than 0.5 acres | 78.5 | 8.5 | 9.0 | 2.4 | 0.8 | 0.8 |
| 0.5–2.0 acres | 61.7 | 13.9 | 15.5 | 3.7 | 4.1 | 1.0 |
| 2.0 acres or more | 49.3 | 9.9 | 18.9 | 9.6 | 9.2 | 3.1 |
| Total | 60.1 | 10.9 | 15.3 | 5.8 | 5.8 | 1.8 |
| Chi-square | | | 154.6 | | 122.5 | |
| Level of significance | | | 0.000 | | 0.000 | |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

households owning more than 2 acres. At the other end of the scale, only 2 percent of the landless population completed more than eight years of schooling, compared with 6 percent from households with more than 2 acres. For each landholding group, however, the distribution pattern is similar in the developed and underdeveloped villages. Only for the group that completed 3-5 years of schooling is the proportion of population larger in developed villages than in underdeveloped ones for the landless and small landowner groups. Thus, it appears that students drop out from primary schools earlier in underdeveloped villages than in developed villages.

The absence of any significant difference in educational levels between the developed and the underdeveloped villages may be interpreted as the consequence of a policy of universal primary education that has been followed in Bangladesh for a long time. But, because this study was not designed to adequately capture the effect of infrastructure on human capital development, this is conjecture. Moreover, years of schooling are not necessarily an indication of the development of cognitive skills (Boissiere, Knight, and Sabot 1985). The effect of infrastructure on development of cognitive skills is expected to be substantial, and it remains an area for further study.

### Health

The survey collected qualitative information on the health of all members of the sample households. Four different categories of health conditions were defined: permanently disabled, chronically ill, occasionally ill, and good health. The distribution of the sample population according to these categories, as reported by each respondent, is seen in Table 62. Nearly 68 percent of the population reported being in good health, 23 percent occasionally ill, 7 percent chronically ill, and 2 percent disabled. Health was better in developed villages: 77 percent of the population were in good health, compared with 61 percent in underdeveloped villages. Seven percent of family members were disabled or chronically ill in developed villages and 11 percent in underdeveloped. The chi-square test shows that the difference is highly statistically significant.

Males were found to be healthier than females in the underdeveloped villages. About 58 percent of the females in these villages were in good health compared with

**Table 62—Health of the sample population in developed and underdeveloped villages, 1982**

| Health Condition | Total Population | | Underdeveloped Villages | | Developed Villages | |
|---|---|---|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Males | Females | Males | Females |
| | | | (percent) | | | |
| Disabled | 2.2 | 1.1 | 1.7 | 2.7 | 1.4 | 0.7 |
| Chronically ill | 8.7 | 5.5 | 8.1 | 9.5 | 5.9 | 5.0 |
| Occasionally ill | 28.5 | 16.8 | 27.0 | 30.0 | 16.2 | 17.4 |
| Good health | 60.6 | 76.7 | 63.3 | 57.8 | 76.5 | 76.8 |
| Sample size | (2,195) | (1,782) | (1,130) | (1,065) | (910) | (872) |
| Chi-square | 130.4 | | 230.9 | | 3.6 | |
| Level of significance | 0.000 | | 0.000 | | 0.469 | |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

63 percent for males, and 2.7 percent of the females were permanently disabled compared with 1.7 percent for males. These findings were statistically highly significant. In developed villages, there was little difference in health between the male and female populations.

When health facilities are less accessible, as in underdeveloped villages, it appears that female members receive less medical care than male members, but the sex discrimination disappears if medical facilities are easily accessible, as in developed villages. After controlling for the effect of sex, infrastructure still has a positive effect on health. Seventy-seven percent of males were in good health in developed villages compared with 63 percent in underdeveloped villages; for females, the proportion was 77 percent to 58 percent.

## Effect on Attitudes and Values

The effect of infrastructure on development of attitudes and values of the rural people is by no means inconsequential. Even though this study did not focus on this aspect of rural development, some results from another study are presented here to show how infrastructure development can influence attitudes toward birth control measures in the predominantly Muslim society of Bangladesh. Under the United Nations Development Programme, a comprehensive survey of about 800 villages was conducted in 1985 in order to evaluate the effect of rural electrification on the adoption of birth control practices (Appendix Table 84) (Hoque 1987). The electrified villages are similar to the developed villages in this study and the nonelectrified villages to the underdeveloped villages. Five out of seven developed villages covered by the 16-village survey had access to electrification, whereas only one out of nine underdeveloped villages had electricity.

It is quite evident from this table that infrastructure development has a substantial impact on the adoption of family planning practices among women. The proportion of women practicing family planning in electrified households was more than twice that in nonelectrified villages. The share of women practicing family planning in households that had not yet been connected to electricity in electrified villages was about 40 percent larger than that in nonelectrified villages. The difference in the adoption rate between electrified and nonelectrified households in electrified villages is largely due to differences in income because those who received electricity earlier are presumably from higher income classes. Therefore, even accounting for the income effect, the net impact of infrastructure development on adoption of family planning practices is remarkably large; on average, developed villages have about twice the adoption rate of underdeveloped villages. Another important point that can be deduced from Appendix Table 84 is the proportionately higher adoption rate among the youngest age group of women in infrastructurally developed villages compared with those in underdeveloped villages. This indicates that infrastructure development generates a proportionately larger attitudinal change among young people, implying that the effect of infrastructure on social change is likely to compound with the progression of time.

## A Recapitulation of the Main Findings

The average yearly prices of paddy and rice, the major commodities traded in rural areas, are higher in developed villages, but the difference is small, 2.4 percent for paddy and 5.7 percent for rice. However, the average masks significant differences across villages and seasons, influenced by such factors as whether the commodity is importable or exportable in the village and the surrounding locality, the per capita income in the locality, and the share of the season's harvest in total yearly output. For paddy, the difference between the lowest and the highest yearly average prices is found to be about 20 percent across villages under study and about 34 percent for the immediate postharvest period. Postharvest prices were very low in villages that produced most of the crop in a single season. The seasonal variation in price was larger for paddy than for rice, and it was higher in underdeveloped villages than in developed ones.

Development of infrastructure is found to have a positive effect on marketing of agricultural produce. Households in developed villages obtain a larger proportion of their basic food needs from the market than those in underdeveloped ones. About 34 percent of the rice consumed by the sample households in developed villages was purchased and 29 percent in underdeveloped villages; for vegetables and tubers, the figures were 72 and 56 percent, respectively. Two-fifths of the paddy output was marketed during the year of survey, 47 percent in developed villages and 35 percent in underdeveloped villages. The marketing ratio was positively correlated with the size of landholding in underdeveloped villages, but the relationship was not found to be systematic in the developed villages. The significantly positive relationship of marketing of paddy with infrastructure development was also confirmed by regression analysis.

The land market is tighter in developed villages than underdeveloped ones. In developed villages, land is sold mostly by the landless and marginal landowners and purchased by medium and large landowners, suggesting a tendency on the part of the nonviable holders to leave farming in response to better job opportunities in nonagricultural activities, thus resulting in the concentration of land in the hands of viable farmers. In the underdeveloped villages this tendency is less pronounced.

Institutional credit covers only a small fraction of rural households and credit requirements; noninstitutional sources are still the dominant conduits of rural credit. All informal credit and most institutional credit are in short-term loans. While access to institutional credit is relatively biased in favor of large landowning groups, the noninstitutional credit market is dominated by borrowers from landless and small landowning classes. The interest rates in the noninstitutional market, on the other hand, are about 10 times as high as in the institutional market. These rates in noninstitutional markets are extremely variable, as if every transaction constituted a separate market.

Infrastructure development is found to improve access to institutional credit almost sevenfold, but again mainly for landowning households. Infrastructure development also transforms the noninstitutional supply system from one dominated by moneylenders and friends and relatives to a system composed largely of moneylenders. Growth of mercantile practices in the credit market is hastened by infrastructure development. The analysis of the utilization of institutional credit reveals a few facets of demand for rural credit. Most institutional credit is used for supplementary working capital in business and for current inputs in agriculture. The demand for credit to finance working capital in business is sharply enhanced by infrastructure development. Use of credit for fixed investment in agriculture is quite small, and infrastructure development does not make much of a difference in this respect. Infrastructure development also contributes positively to the shift of allocation of credit from nonproductive to productive activities and to increased demand for credit in nonagricultural activities.

The development of infrastructure did not have a significant effect on the literacy rate, which is affected more by the size of landholding of the household and the sex of the member. Dropping out of primary school for those who belong to the landless and small landowning groups is earlier in underdeveloped villages than in developed ones. The development of infrastructure, however, has a significant impact on health conditions and acceptance of family planning practices.

# 10

# IMPLICATIONS FOR PUBLIC POLICIES

If infrastructure development is as crucial an element for rural development as the previous chapters have shown, why do most governments fail to accord appropriate priority to it? Analysis of public expenditures on the road and transport sector, the central component of infrastructure, in 45 developing countries, indicates that in an early stage of economic development, governments generally allot a relatively small share to this sector, a share that gradually increases as the country's economic status approaches the lower-middle-income category (using the World Bank's classification system). Thereafter, infrastructure's share of public expenditure starts to fall. When urban-oriented infrastructure development approaches saturation and the task of development of the rural road network begins, priority directed to infrastructure development declines rapidly, perhaps reflecting what Lipton (1977) generalizes to be the urban bias in most development policies.

In light of the extensive developmental effects of rural infrastructure, which are brought out in various sections of this study, the following implications for public policies are of strategic importance.

## Development Strategy and Infrastructure

It is argued here that development of rural infrastructure has to play a key role in any development strategy for Bangladesh, and such a strategy must emphasize growth and equity. Without growth, distribution of income implies the sharing of poverty. But, emphasis on growth alone is likely to accentuate the poverty in which the majority exist, creating political instability that will drag down growth itself. A development strategy for growth and equity generally places priority on agriculture and labor-intensive industrialization. Emphasis on agriculture is understandable because agriculture is the major source of income for rural people, most of whom are not rich. In order for this vast majority to participate in the process of development, agriculture has to be given priority. But there are other substantive grounds for according priority to agriculture. Agriculture produces food. If production stagnates, given population growth, food prices will go up and import demand for food may adversely affect the foreign exchange available for development projects. Higher food prices may create labor problems and suffocate the growth of industries. Moreover, since agriculture continues to be the largest source of exports, agricultural stagnation may also mean stagnation of exports. Therefore, agriculture is a critical sector in the strategy for growth and equity.

The emphasis on *labor-intensive* industrialization is also understandable, particularly in the context of medium- and long-run development. Capital for industrialization is in extremely short supply. Unless this limited supply of capital is spread thinly over a large stock of employable labor, the growth and equity objective is jeopardized. In a country where land is limited and the pressure of population on land is so high, surplus labor in agriculture must be accommodated through expansion of the nonagricultural sector in the long run. Employment-oriented industrialization is therefore another component of a development strategy that aims for growth with equity.

Although it is easy to make broad generalizations on development strategy, it is extremely difficult to prescribe how to accomplish it. By observing government programs in Bangladesh that, at least in documents, claim to pursue a growth-equity strategy, some facts can be gleaned about how the strategy is working in practice. In both agricultural and industrial sectors, the country is pursuing a policy of generating momentum in production through the private sector, although the past legacy of public initiative still lingers. On the agricultural front, generation and diffusion of modern technology in agriculture (spread of HYVs, fertilizer, and irrigation) through comprehensive research, extension, credit, and input marketing programs have been the principal instruments used to accelerate the pace of production. Nevertheless, diffusion of technology has remained slow. Arguments for enhancing incentives through input subsidies have emerged strongly every time the level of use of inputs has shown a tendency to decline. Placing priority on technology is no doubt defensible and wise, but it is argued and evidences have been shown that the missing link is the incommensurate priority given to development of rural infrastructure. Infrastructure reinforces the effectiveness of the diffusion of technology, and technology reinforces the benefits from infrastructure.

The industrialization program is based on selective public participation in direct production, credit, and protective trade policies and on extension of advisory services. The experience of industrialization has been even more frustrating than that of agriculture. But even though the overall outcome for industrialization has been frustrating, the informal small-scale sector has grown much faster than expected. Khan and Hossain (1990) show that whatever industrial growth in value added and employment has occurred in Bangladesh is the result of growth from small-scale industries, particularly cottage industries (see Appendix Table 85). It is these small-scale industries that are labor-intensive and consistent with the proclaimed development strategy.

A number of factors that make infrastructure and industrialization quite interdependent are worth highlighting here. Industrialization through small-scale businesses involves a process of changing from the type of entrepreneurship that exists between large farms and commercial traders to small-scale industrial entrepreneurship. This transition can flourish only when risk is relatively small, transaction costs are low, and marketing procedures are relatively easy. Infrastructure development has a critical influence on all these factors. Domestic demand is an extremely effective conduit for reducing market risk, and Chapter 7 shows how infrastructure development supports that demand for manufactured consumer goods. The marketing costs and access of rural households to consumer goods are all favorably influenced by infrastructure development. Small-scale units tend to be located near rural towns for this reason. Once confidence has developed among the entrepreneurs on the basis of domestic demand, efficiency improves, and the small-scale producers of industrial goods seek international markets that further stimulate their activities. It is easier to move from a small-scale phase to large-scale industrialization than to begin with large-scale, capital-intensive industries under public or protected private sectors. Infrastructure development that links rural households with the rest of the economy is critical for the success of this strategy of industrialization.

## Approaches to Public Investment Decisions

Development of infrastructure has high costs in resources. Public resources have competing demands. Therefore, decisions on allocation of public resources to infrastructure cannot be made without some criteria on rate of return. If all conceivable projects covering all public-sector investments could be identified and their rates of return estimated, they could be ranked according to these rates of return. Then all budgetary resources could be allocated to the top-ranking projects. Unfortunately, this ideal approach is seldom practiced and may not even be practicable.

Allocation of public-sector development resources is generally conducted in two stages. In the first stage, intersectoral allocations are made, keeping intermediate and long-term objectives in view, in accordance with the investment requirements for matching the profile of production with that of demand for commodities and services. These intersectoral allocations are continually adjusted through annual programming and budgeting procedures. This commodity-oriented mechanism for allocating resources to sectors is inherently biased against infrastructure because of the general deficiency in information on the productivity of infrastructure relative to that of direct production inputs. This results in a somewhat arbitrary treatment in allocating resources for infrastructure development. Realizing the problems of assessing the proper impact of infrastructural investment and the complementary roles of infrastructure and directly productive investment, Hirschman (1958) argues that in "a country plagued by deficiency of demand and high costs of production, a development oriented government may do well by creating a surplus of social overhead capital." In the case of contemporary developing countries, particularly in Africa, Hirschman's argument is extremely relevant.

At the second level of resource allocation, intrasectoral allocations among projects are made when benefit-cost analysis serves as one of the tools for making choices among alternatives. Therefore, at this level, and through the benefit-cost analysis, the sectoral resource allocation cannot be affected. This obvious statement is placed here only to counter the observation often made by critics that resources are not adequately allocated to infrastructure development because benefit-cost analysis often does not support such increased allocation. Even though traditional benefit-cost analysis is hardly instrumental in causing change in sectoral allocation to infrastructure, it is very useful for ensuring efficiency in resource use, given a sectoral allocation.

Benefit-cost analysis of infrastructural projects (a rural road, for example) is a nightmare to analysts primarily because of the complexities of identifying multifaceted benefits and measuring them in a dynamic world. The cost side is relatively easy to identify and measure. The evolution of this analytical tool in project appraisal by national and international agencies reflects these complexities. Moler (1987) and Beenhakker et al. (1987) present some useful surveys on the World Bank's use of benefit-cost analysis for road and transport projects. The conventional approach is to consider cost savings to road users as the main benefit. Therefore, the total benefit depends on total traffic volume (that is, the current and incremental traffic as the result of the project) and the cost saving per unit of traffic (the reduction in the cost of transport due to the road). Savings in time-cost are talked about but excluded in most analyses because of the difficulty of measuring them. The measurement of the traffic volume is critical and cannot simply be proxied by a factor of current level of traffic, even when improvement of the road is involved. For example, a study in Bangladesh shows that the benefit-cost ratio for improving a deteriorated earth road to a paved road is 1.19 if only the existing traffic is taken into account. If the incremental volume of traffic arising from this improvement is taken into account, the benefit-cost ratio becomes 3.48 (Chowdhury and Hossain 1985). Such is the magnitude of difference in the ratio due to the generation of additional traffic. Measurement of what would realistically happen after the road is improved or constructed is therefore a critical task of assessment. Most analyses assume an arbitrary constant rate of increase in traffic volume, without much of a basis to support the assumptions.

Assessing the nature of the demand curve for transport in a dynamic context is fundamental in order to assume a realistic rate of increase in traffic volume. The demand for transport will depend on the impact of the road on agricultural production, increases of the marketing ratio from commercialization, and changes in consumption patterns. Accessibility may change the consumption pattern so that more consumer goods produced in urban centers will be available and consumed in the area covered by roads, thus increasing the demand for transport.

It is clear that a benefit-cost analysis based on user cost saving and volume of traffic does not take any account of employment, income distribution, or social development of the type discussed in various chapters of this manuscript. Concerns for these effects of road development have motivated analysts and international development agencies to design multiple criteria appraisal methods (Moler 1987; Beenhakker et al. 1987). Application of such methods in real situations has remained limited, and the adoption of such methods is also dependent on subjective weights assigned to each objective. Therefore, formal benefit-cost analysis for appraisal of infrastructural projects has remained quite weak. Judgment of policymakers has served in the past and will continue to serve as a strong basis for public investment decisions. If some error in judgment is unavoidable, it is preferable to overinvest than to underinvest in rural infrastructure. What is needed to improve the objective basis of decisionmaking is more studies of the developmental effects of infrastructure:

Besides the rate-of-return criterion, there are a number of popular perceptions that foster antagonism to increased allocation of resources to rural infrastructure:

1. *Infrastructure development makes the rich richer and the poor poorer.*

Arguments pro and con the effects of infrastructure development on poverty are as follows. The antagonists argue that the distribution of benefits from infrastructure development is determined by the initial ownership of land and other assets, including liquid capital. Because infrastructure development generates its benefits through improvement in productivity of these assets, it is the rich who mainly benefit. This is the standard argument advanced in the context of most development policies.

The protagonists argue their case from several angles. First, they argue that the poor may be short in land and capital, but they have labor to offer. Therefore, the effects on wage rates and employment must be considered in judging the poverty-alleviating impact of infrastructure development. Wage income may rise faster than agricultural income and profit because, as shown earlier, infrastructure development leads to an increase in demand for hired labor as the result of diffusion of technology and growth of nonfarm activities. The demand for hired labor may also increase because the supply of family labor may be reduced in richer households if members choose leisure over income. This is an empirical issue, however.

Second, a majority of the rural poor (small farmers and the landless) have some land and capital, which, when combined with abundant labor, is an advantage in labor-intensive, small-scale livestock production, fishing, and vegetable growing in areas that have ready access to markets for these products. The absence of an immediate access to markets is a definite constraint in production of these perishable products. Infrastructure development removes that constraint.

Third, public programs for the poor are more effective if the level of infrastructure development is higher. The ineffectiveness of famine prevention measures in areas of infrastructural underdevelopment is too well known to repeat. Finally, it is argued that if special care is taken in implementing programs for the poor (such as the Grameen Bank program in Bangladesh), credit can be extended to the poor so that they can avail themselves of the opportunities created by infrastructure development.

Even if development of rural infrastructure makes asset-holding households richer at a rate faster than it increases the income of assetless households, the increase in the absolute level of income of the poor is what matters. Although most development processes tend to increase the income of rich households faster than poor households in the early phase of development, that can hardly be a serious argument against pursuing development.

2. *Infrastructure development in rural areas is wasteful without supplementary measures.*

The essence of this popular allegation has never been clearly spelled out. Sometimes it is said that road development in a desert is wasteful. Sometimes it is argued that educated people will leave rural areas if infrastructure is developed. Sometimes it is argued that road development alone will not cause any increase in benefits if other measures are not also taken.

Nobody argues for development of a road in a desert for its own sake. But if a road in a desert has the potential to attract tourists, it may not be a bad proposition. The question of whether to build a road should be based on the potential of increasing production—not on the existing production. That the African population is sparse and the production level low in certain locations is not a serious argument against development of infrastructure in Africa: the potential for production and for relocation of population should be the main concern.

The argument that educated people will move out of rural areas is a nebulous one. If life is attractive in rural areas and jobs are available for educated young people, they will not go to urban areas. Educated people are more likely to be retained in rural areas when infrastructure exists—not the other way around.

The question of supplementary measures (appropriate public institutions, trade policies, regulations, and so forth) to make investment in roads more productive is a valid one. This is precisely the reason why infrastructure has to be defined broadly. But again, the protagonists of this argument often are misled by unclear thinking. One has to distinguish between supplementary measures that must be created by government and those that will automatically come through private investment (with a time lag), because the ultimate purpose of infrastructure is to create an environment for private investment.

3. *Infrastructure development leads to widespread corruption.*

It is argued that development of rural infrastructure through local officials and politicians increases corruption. Protagonists who raise this issue apparently assume that there is no corruption at higher levels of public service and political leadership. On the contrary, it can be argued that the rate of corruption (defined as leakage per unit of total public expenditure) will probably be higher at higher levels. A local leader with a wealth of Tk 50,000 may hesitate to usurp Tk 5,000 from a public expenditure of Tk 100,000. But a highly placed policymaker may not hesitate to milk Tk 5 million from a public investment of Tk 50 million. The allegation of corruption cannot be raised against rural infrastructure alone; it has to be examined within the overall context of a country's economic, political, and administrative structures.

## Donor Policies on Infrastructure

Infrastructure development in developing countries has historically been greatly influenced by the foreign aid policies of donors. The World Bank's emphasis on high priority for infrastructure development reached its peak during the 1960s and then began to drop drastically. The transport sector's share of World Bank lending dropped from 35 percent in 1970-74 to 17 percent in 1980-84. Country-specific studies on public expenditure also show the significant influence of foreign aid on allocations to transport, communications, and electricity. Donors must recognize the pivotal role of infrastructure in economic development and review their lending for infrastructure development. It is a paradox in donor policies that, whereas they emphasize market mechanisms to play an increasing role in development, they attach a declining priority to infrastructure development. Macroeconomic concerns, often reflected in conditions placed on foreign aid geared to reduce public expenditures, should be mitigated by the elimination of expenditures on purposes that could be performed by the private sector, not by cutting back allocations for infrastructure development. Decisions on investment in infrastructure should be separated from decisions on the relative roles of private and public sectors. Keeping the two kinds of decisions separate will enable a rational allocation of resources to infrastructural investment.

Because wage goods constitute an important component of the cost of infrastructure development, food aid is a particularly important resource for development of rural infrastructure. However, the distinction between food aid to finance infrastructure development and infrastructure development as an outlet or basis for food aid is a subtle and significant difference that must be maintained to protect the image of infrastructural priority. Infrastructural projects must stand on their own merit, and food aid should be considered a resource like any other resource. Without this distinction, infrastructure development may become the secondary objective and food aid the primary one. Food aid could be a quite effective tool in containing inflation arising from increased public expenditures, particularly in chronic food deficit countries.

## Development and Maintenance of Infrastructure

Problems with maintenance are perhaps the most formidable constraints to development of rural infrastructure. In a related but separate exercise, an attempt was made to estimate the amount of financial resources required for development of rural infrastructure in Bangladesh, so that all villages in the country could be developed to the level of the three most developed villages in this study (IFPRI/BIDS 1988). Questions of maintenance and institutional requirements were also examined in that exercise, four generalizations from which are pertinent to this paper:

1. The initial investment required for construction of facilities is large but can be accommodated within a five-year frame of government resources provided priorities are rearranged. This is not a serious constraint if the government is committed to rural development.

2. Institutional constraints are far more difficult to overcome. For development and maintenance of rural infrastructure, effective local organizations—local governments at the *upazila* level—are of critical importance. At present, local governments do not have the power necessary to generate local resources, have limited authority in decision-making, and are not adequately supported by staff with technical skills such as engineers. It is essential to correct these deficiencies by turning local governments into effective institutions for governance and development of rural areas.

3. Financial resources of a recurring nature must flow regularly to the treasuries of local governments. This is essential for maintaining rural infrastructure. Maintenance of rural roads and markets is critical to sustaining the productive use of these facilities. A part of the land revenue currently going to the central government and additional taxes on the local industries, business, and trades that will benefit from the infrastructure should become sources of a regular flow of resources to local governments. The principles

of sharing land revenues and imposing new local taxes must be institutionalized. Again, none of these constraints are unsolvable if political will and commitment to rural development are strong.

4. Generation of resources by local communities for investment in infrastructure is a substitute for the "market test" of whether such investments are worthwhile, if it is linked as a condition to the allocation of resources from the central government.

# APPENDIX: SUPPLEMENTARY TABLES

## Table 63—Results of factor analysis of infrastructure variables in 16 villages

| Original Variable | Rotated Factor Matrix |  | Communality $h^2$ | Weights Used in the Index[a] |
|---|---|---|---|---|
|  | 1 | 2 |  |  |
| Primary market | 0.7508 | −0.2091 | 0.6074 | 0.443 |
| Secondary market | 0.8885 | 0.3420 | 0.9063 | 0.655 |
| Bus station | 0.9176 | −0.0296 | 0.8428 | 0.625 |
| Bank | 0.6446 | 0.5505 | 0.7186 | 0.506 |
| Secondary school | −0.0713 | 0.8621 | 0.7483 | 0.545 |
| *Upazila* center | 0.8410 | 0.6470 | 0.7114 | 0.405 |
| Primary school | 0.4668 | 0.1415 | 0.2379 | NI |
| Rail station | −0.3188 | 0.2671 | 0.1729 | NI |
| Post office | 0.4418 | −0.0458 | 0.1973 | NI |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] These are the weights used in the construction of indexes described in the main text (the correlation of $IC_i$ with TC). NI means these variables are not included in the index.

## Table 64—Distribution of income from livestock and fisheries, by landownership group, 1982

| Landownership Group/Size of Farm | Share in Total Income |  |  |  |
|---|---|---|---|---|
|  | All Households | Developed Villages | Underdeveloped Villages | Difference |
|  | (percent) |  |  |  |
| Landless | 26.4 | 33.0 | 19.0 | 73.7 |
| Land owned |  |  |  |  |
| Small | 24.3 | 25.4 | 22.9 | 10.9 |
| Medium | 27.5 | 23.4 | 32.2 | −27.3 |
| Large | 21.8 | 18.2 | 25.9 | −29.7 |
| Total | 100.0 | 100.0 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

### Table 65—Per capita income from livestock and fisheries, by landownership group, 1982

| Landownership Group | All Households | Developed Villages | Underdeveloped Villages | Difference |
|---|---|---|---|---|
| | | (Tk) | | (percent) |
| Landless | 245.4 | 334.6 | 160.1 | 109.0 |
| Land owned | | | | |
| Small | 178.1 | 193.1 | 162.3 | 19.0 |
| Medium | 210.2 | 241.6 | 191.6 | 26.1 |
| Large | 356.0 | 432.7 | 311.5 | 38.9 |
| Average | 229.8 | 270.7 | 195.7 | 38.3 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

### Table 66—Distribution of income from business and industries by landownership group, 1982

| | Share in Total Income | | | |
|---|---|---|---|---|
| Landownership Group | All Households | Developed Villages | Underdeveloped Villages | Difference |
| | | (percent) | | |
| Landless | 22.8 | 22.0 | 23.6 | −6.9 |
| Land owned | | | | |
| Small | 28.1 | 20.2 | 35.3 | −42.8 |
| Medium | 20.5 | 25.3 | 16.0 | 58.1 |
| Large | 23.6 | 32.5 | 25.1 | 29.5 |
| Total | 100.0 | 100.0 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 67—Per capita income from business and industry, by landownership group, 1982

| Landownership Group | All Households | Developed Villages | Underdeveloped Villages | Difference |
|---|---|---|---|---|
| | | (Tk) | | (percent) |
| Landless | 274.1 | 260.5 | 286.4 | −9.0 |
| Land | | | | |
| Small | 266.7 | 179.5 | 359.8 | −50.1 |
| Medium | 202.3 | 305.5 | 136.6 | 123.7 |
| Large | 605.9 | 902.5 | 434.0 | 108.0 |
| Average | 297.4 | 316.4 | 281.4 | 12.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 68—Distribution of wage income by landownership group in developed and underdeveloped villages, 1982

| | Share in Total Wage Income | | |
|---|---|---|---|
| Landownership Group | Developed Villages | Underdeveloped Villages | Difference |
| | | (percent) | |
| Landless | 42.3 | 50.7 | −16.6 |
| Land owned | | | |
| Small | 41.3 | 30.9 | 33.6 |
| Medium | 15.2 | 13.5 | 12.6 |
| Large | 1.2 | 4.9 | −75.7 |
| Total | 100.0 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 69—Per capita wage income, by landownership group, in developed and underdeveloped villages, 1982

| Landownership Group | Developed Villages | Underdeveloped Villages | Difference |
|---|---|---|---|
| | (Tk) | | (percent) |
| Landless | 945.0 | 693.2 | 36.3 |
| Land owned | | | |
| Small | 690.3 | 354.0 | 95.0 |
| Medium | 345.1 | 130.3 | 164.9 |
| Large | 67.2 | 95.3 | −29.5 |
| Total | 596.3 | 317.0 | 88.1 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 70—Per capita income from miscellaneous sources by landownership group in developed and underdeveloped villages, 1982

| Landownership Group | Developed Villages | Underdeveloped Villages | Difference |
|---|---|---|---|
| | (Tk) | | (percent) |
| Landless | 436.0 | 489.0 | −10.8 |
| Land owned | | | |
| Small | 517.7 | 601.9 | −14.0 |
| Medium | 615.9 | 735.9 | −16.3 |
| Large | 778.4 | 795.4 | −2.1 |
| Average | 550.9 | 651.4 | −15.4 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Difference = [(Developed − Underdeveloped)/Underdeveloped] × 100. Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 71—Incidence of rural taxes, developed and underdeveloped areas

| Landownership Group | Average Family Income | Average Taxes Paid | Effective Tax Rate |
|---|---|---|---|
| | (Tk) | | (percent) |
| Developed area | 20,385 | 59.1 | 0.29 |
| Landless | 13,015 | 7.8 | 0.06 |
| Land owned | | | |
| Small | 17,602 | 35.2 | 0.20 |
| Medium | 25,805 | 95.5 | 0.37 |
| Large | 47,644 | 176.3 | 0.37 |
| Underdeveloped area | 18,893 | 34.1 | 0.18 |
| Landless | 10,016 | 4.0 | 0.04 |
| Land | | | |
| Small | 13,975 | 14.0 | 0.10 |
| Medium | 23,202 | 34.8 | 0.15 |
| Large | 45,109 | 112.8 | 0.25 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: Landless own 0 to less than 0.5 acres, small owners own 0.5 to less than 2.5 acres, medium owners own 2.5 to less than 5.0 acres, and large owners own 5.0 acres or more.

## Table 72—Estimated regression equations on wage income

| Equation Number | Equation | $\bar{R}^2$ |
|---|---|---|
| 20 | $\text{WGEI} = \underset{(1.56)}{42.675} + \underset{(10.69)}{56.28}\ \text{WRKR} + \underset{(1.72)}{2.273}\ \text{EDCN} - \underset{(-6.13)}{8.357}\ \text{INF}$<br>$+ \underset{(1.906)}{2.09}\ \text{WGRT} - \underset{(-1.50)}{0.0007}\ \text{CPTL} - \underset{(-5.02)}{50.95}\ \text{FEM} - \underset{(-3.89)}{0.159}\ \text{HYV}$<br>$- \underset{(-1.987)}{3.347}\ \text{FSZ} - \underset{(-3.175)}{0.099}\ \text{LAND}$ | 0.37 |
| 21 | $\text{FEM} = \underset{(5.99)}{0.458} - \underset{(-3.68)}{0.026}\ \text{INF} - \underset{(-1.073)}{0.0008}\ \text{FSZ}$ | 0.15 |
| 22 | $\text{WRKR} = \underset{(7.28)}{0.92} + \underset{(10.37)}{0.14}\ \text{FSZ} + \underset{(0.70)}{0.007}\ \text{INF} + \underset{(0.03)}{7.9\text{E-}0.6}\ \text{LAND}$ | 0.17 |
| 23 | $\text{LAND} = \underset{(-0.465)}{-12.685} + \underset{(0.86)}{2.159}\ \text{INF} + \underset{(7.918)}{21.88}\ \text{FSZ}$ | 0.13 |
| 24 | $\text{HYV} = \underset{(5.72)}{0.90} + \underset{(16.48)}{0.788}\ \text{IRGN} - \underset{(-5.33)}{0.137}\ \text{LAND} + \underset{(1.97)}{0.0107}\ \text{CPTL}$<br>$+ \underset{(5.04)}{0.0196}\ \text{CRDTI} + \underset{(3.91)}{0.0117}\ \text{CRDTNI} - \underset{(-2.27)}{0.0411}\ \text{INF}$ | 0.51 |
| 25 | $\text{CPTL} = \underset{(1.974)}{2193.956} + \underset{(7.979)}{20.127}\ \text{LAND} - \underset{(-0.732)}{99.8157}\ \text{INF}$ | 0.13 |
| 26 | $\text{EDCN} = \underset{(5.099)}{2.153} - \underset{(-2.114)}{0.1056}\ \text{INF} + \underset{(6.102)}{0.006}\ \text{LAND}$ | 0.29 |
| 27 | $\text{WGRT} = \underset{(36.25)}{20.06} + \underset{(2.170)}{0.129}\ \text{EDCN} - \underset{(-2.695)}{0.176}\ \text{INF}$ | 0.14 |

*The figures in parentheses are t-values.

**Table 73—Estimated regression equations on livestock and fisheries income**

| Equation Number | Equation | $\bar{R}^2$ |
|---|---|---|
| 28 | $\text{LIFSI} = \underset{(2.70)}{915.86} + \underset{(0.267)}{7.64}\,\text{EDCN} + \underset{(1.685)}{167.41}\,\text{NWCH} + \underset{(4.63)}{500.19}\,\text{WRKR}$<br>$- \underset{(-4.43)}{132.94}\,\text{INF} + \underset{(3.04)}{926.67}\,\text{PLBA} + \underset{(1.48)}{0.026}\,\text{CPTLA} + \underset{(0.59)}{140.60}\,\text{FEM}$<br>$+ \underset{(3.30)}{1.43}\,\text{LAND} - \underset{(-1.23)}{123.93}\,\text{ANML}$ | 0.45 |
| 29 | $\text{EDCN} = \underset{(5.099)}{2.153} - \underset{(-2.114)}{0.1056}\,\text{INF} + \underset{(6.102)}{0.006}\,\text{LAND}$ | 0.29 |
| 30 | $\text{NWCH} = \underset{(4.08)}{0.50} - \underset{(-5.87)}{0.22}\,\text{WRKR} - \underset{(-1.42)}{0.015}\,\text{INF} - \underset{(-0.50)}{6.5\text{E-}05}\,\text{LAND} + \underset{(13.30)}{0.185}\,\text{FSZ}$ | 0.25 |
| 31 | $\text{WRKR} = \underset{(7.28)}{0.92} + \underset{(10.37)}{0.14}\,\text{FSZ} + \underset{(0.70)}{0.007}\,\text{INF} + \underset{(0.03)}{7.9\text{E-}0.6}\,\text{LAND}$ | 0.17 |
| 32 | $\text{PLBA} = \underset{(0.50)}{0.023} - \underset{(-1.128)}{0.016}\,\text{WRKR} - \underset{(-1.555)}{0.006}\,\text{INF} + \underset{(9.82)}{4.8\text{E-}04}\,\text{LAND} + \underset{(1.16)}{0.006}\,\text{FSZ}$ | 0.17 |
| 33 | $\text{CPTLA} = \underset{(1.77)}{1{,}243.89} + \underset{(1.73)}{395.11}\,\text{WRKR} - \underset{(-1.73)}{119.21}\,\text{INF} + \underset{(11.73)}{9.15}\,\text{LAND}$ | 0.19 |
| 34 | $\text{FEM} = \underset{(5.99)}{0.458} - \underset{(-3.68)}{0.026}\,\text{INF} - \underset{(-1.073)}{0.0008}\,\text{FSZ}$ | 0.15 |
| 35 | $\text{LAND} = \underset{(-0.465)}{-12.685} + \underset{(0.86)}{2.159}\,\text{INF} + \underset{(7.918)}{21.88}\,\text{FSZ}$ | 0.13 |
| 36 | $\text{ANML} = \underset{(-1.39)}{-0.20} + \underset{(2.40)}{0.107}\,\text{WRKR} + \underset{(2.04)}{0.026}\,\text{INF} + \underset{(4.65)}{0.08}\,\text{FSZ} + \underset{(13.18)}{0.002}\,\text{LAND}$ | 0.36 |

Notes: The figures in parentheses are t-values. The variables are defined in the text.

## Table 74—Estimated regression equations on income from business and industries

| Equation Number | Equation | $\bar{R}^2$ |
|---|---|---|
| 37 | BSINDI = 248.78 + 2.06 CRDNI + 407.97 WRKR + 0.39 CPTLB<br>(0.33) (1.78) (1.77) (9.33) | |
| | + 80.80 EDCN − 41.92 INF + 5.70 CRDI + 0.87 LAND<br>(1.22) (−0.60) (3.25) (1.05) | 0.19 |
| 38 | CPTLB = 60.09 + 8.41 CRDI + 476.13 WRKR − 70.04 INF + 76.76 EDCN<br>(0.80) (5.12) (2.18) (−1.06) (1.21) | |
| | − 1.42 CRDNI + 1.45 LAND<br>(−1.14) (1.84) | 0.16 |
| 39 | WRKR = 0.92 + 0.14 FSZ + 0.007 INF + 7.9E-0.6 LAND<br>(7.28) (10.37) (0.70) (0.03) | 0.17 |
| 40 | EDCN = 2.153 − 0.1056 INF + 0.006 LAND<br>(5.099) (−2.114) (6.102) | 0.29 |
| 41 | LAND = −12.685 + 2.159 INF + 21.88 FSZ<br>(−0.465) (0.86) (7.918) | 0.13 |
| 42 | CRDI = 6.43 − 1.21 INF + 0.07 LAND + 0.69 EDCN + 0.20 HYV<br>(0.44) (−0.73) (3.59) (0.45) (5.58) | 0.10 |
| 43 | CRDNI = 72.23 − 3.23 INF − 0.003 LAND + 6.17 EDCN + 0.30 HYV<br>(3.76) (−1.48) (−0.13) (3.07) (6.26) | 0.09 |

Note: The figures in parentheses are t-values.

## Table 75—Expenditure pattern, by developed and underdeveloped villages, 1982

| Consumption Item | Developed Villages | | | Underdeveloped Villages | | |
|---|---|---|---|---|---|---|
| | Average Budget Share | Marginal Budget Share | Expenditure Elasticity | Average Budget Share | Marginal Budget Share | Expenditure Elasticity |
| | (percent) | | | (percent) | | |
| Cereals | 47.5 | 30.9 | 0.65 | 59.6 | 47.6 | 0.80 |
| Rice | 41.9 | 31.7 | 0.76 | 51.3 | 48.1 | 0.94 |
| Wheat | 5.6 | −0.8 | −0.14 | 8.2 | −0.5 | −0.06 |
| Kaon, maize | 0.0 | 0.0 | 0.00 | 0.1 | 0.0 | 0.20 |
| Potatoes and sweet potatoes | 1.8 | 1.3 | 0.72 | 1.6 | 1.7 | 1.08 |
| Green vegetables | 3.2 | 1.9 | 0.59 | 3.8 | 3.2 | 0.84 |
| Pulses | 0.6 | 0.9 | 1.50 | 0.8 | 1.2 | 1.50 |
| Spices | 3.9 | 3.7 | 0.95 | 3.0 | 2.5 | 0.83 |
| Narcotics | 3.9 | 4.5 | 1.15 | 2.3 | 1.8 | 0.78 |
| Biri | 1.8 | 1.1 | 0.61 | 1.4 | 0.8 | 0.57 |
| Cigarettes | 0.5 | 1.2 | 2.40 | 0.0 | 0.0 | 0.00 |
| Betel leaf and nuts | 1.4 | 1.7 | 1.21 | 0.8 | 0.9 | 1.13 |
| Tobacco and jarda | 0.2 | 0.5 | 0.25 | 0.1 | 0.1 | 1.00 |

*(continued)*

## Table 75—Continued

| Consumption Item | Developed Villages: Average Budget Share | Developed Villages: Marginal Budget Share | Developed Villages: Expenditure Elasticity | Underdeveloped Villages: Average Budget Share | Underdeveloped Villages: Marginal Budget Share | Underdeveloped Villages: Expenditure Elasticity |
|---|---|---|---|---|---|---|
| | (percent) | | | (percent) | | |
| Sugar products | 1.5 | 2.8 | 1.87 | 1.4 | 2.0 | 1.48 |
| Molasses *(gur)* | 1.1 | 1.9 | 1.73 | 1.3 | 1.7 | 1.31 |
| Sugar | 0.4 | 0.9 | 2.25 | 0.1 | 0.3 | 4.85 |
| Tea | 1.1 | 1.3 | 1.18 | 0.0 | 0.0 | 0.40 |
| Oils | 2.7 | 3.1 | 1.15 | 2.3 | 2.4 | 1.02 |
| Soybean oil | 0.3 | 0.2 | 0.67 | 0.3 | 0.3 | 1.00 |
| Mustard oil | 1.8 | 2.3 | 1.28 | 1.7 | 1.8 | 1.06 |
| Coconut oil | 0.5 | 0.5 | 1.00 | 0.3 | 0.3 | 0.93 |
| Vegetable ghee | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 0.00 |
| Fruits | 1.3 | 2.6 | 2.00 | 1.8 | 2.4 | 1.33 |
| Milk and milk products | 0.9 | 2.2 | 2.44 | 0.3 | 1.4 | 4.52 |
| Milk and curds | 0.8 | 2.0 | 2.50 | 0.3 | 1.3 | 4.33 |
| Powdered milk | 0.0 | 0.0 | 0.00 | 0.0 | 0.1 | 5.00 |
| Sweetmeats | 0.1 | 0.2 | 2.00 | 0.0 | 0.1 | 5.00 |
| Fish, meat, and eggs | 6.2 | 9.9 | 1.59 | 4.1 | 6.5 | 1.58 |
| Eggs | 0.3 | 0.5 | 1.67 | 0.3 | 0.6 | 2.00 |
| Fish | 4.8 | 6.2 | 1.29 | 2.9 | 3.3 | 1.14 |
| Meat | 1.1 | 3.2 | 2.91 | 0.9 | 2.6 | 2.89 |
| Total food | 74.6 | 65.1 | 0.87 | 81.0 | 72.8 | 0.90 |
| Fuels and energy | 8.3 | 7.2 | 0.87 | 8.7 | 5.5 | 0.63 |
| Firewood | 2.2 | 2.2 | 1.00 | 2.2 | 2.2 | 1.00 |
| Jute sticks | 1.7 | 2.2 | 1.29 | 0.3 | 0.2 | 0.67 |
| Rice husks | 0.3 | 0.3 | 1.00 | 0.9 | 0.6 | 0.67 |
| Cow dung | 1.3 | −0.1 | −0.08 | 1.6 | 0.4 | 0.25 |
| Dry leaves | 1.2 | 0.5 | 0.42 | 2.3 | 0.8 | 0.35 |
| Kerosene | 1.4 | 1.3 | 0.93 | 1.4 | 1.3 | 0.93 |
| Electricity | 0.2 | 0.8 | 4.00 | 0.0 | 0.0 | 0.00 |
| Other consumer goods | 1.9 | 2.4 | 1.29 | 1.4 | 2.2 | 1.55 |
| Match sticks | 0.4 | 0.2 | 0.50 | 0.3 | 0.1 | 0.33 |
| Soap | 0.9 | 1.4 | 1.56 | 0.7 | 1.3 | 1.86 |
| Washing soda | 0.2 | 0.1 | 0.50 | 0.2 | 0.1 | 0.50 |
| Cosmetics and toothpaste | 0.1 | 0.2 | 2.00 | 0.0 | 0.2 | 10.00 |
| Shoes and leather goods | 0.3 | 0.5 | 1.67 | 0.0 | 0.5 | 2.50 |
| Clothes | 5.6 | 9.7 | 1.73 | 5.2 | 9.2 | 1.77 |
| Handloom clothes | 2.7 | 4.9 | 1.81 | 3.2 | 3.9 | 1.22 |
| Mill-made clothes | 1.4 | 1.7 | 1.21 | 0.4 | 1.6 | 4.00 |
| Ready-made clothes (domestic) | 0.7 | 0.9 | 1.29 | 0.4 | 0.7 | 1.75 |
| Ready-made clothes (foreign) | 0.2 | 1.2 | 6.00 | 0.7 | 2.1 | 3.00 |
| Old clothes | 0.3 | 0.2 | 0.67 | 0.3 | 0.2 | 0.67 |
| Other clothes | 0.3 | 0.8 | 2.67 | 0.2 | 0.7 | 3.50 |
| Services | 9.3 | 15.7 | 1.70 | 3.3 | 9.9 | 3.00 |
| Education | 0.5 | 1.7 | 3.40 | 0.1 | 2.0 | 3.33 |
| Health and medicine | 2.7 | 3.5 | 1.29 | 1.5 | 3.1 | 2.07 |
| Transport | 1.2 | 2.2 | 1.83 | 0.4 | 0.8 | 2.00 |
| Personal services | 0.9 | 0.9 | 1.00 | 0.3 | 0.3 | 1.00 |
| Religious services | 3.6 | 5.4 | 1.59 | 0.3 | 2.1 | 7.00 |
| Other miscellaneous services | 0.4 | 2.0 | 5.00 | 0.2 | 1.6 | 8.00 |
| Total nonfood | 25.1 | 35.0 | 1.40 | 18.6 | 26.8 | 1.44 |
| Total of all expenditures | 100.0 | 100.0 | . . . | 100.0 | 100.0 | . . . |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: Totals may not add up exactly to 100.0 due to rounding.

## Table 76—Consumption expenditure functions: selected variables

| Commodity | Constant | Log Total Expenditure | Total Expenditure Share | Infrastructure | Infrastructure Share | Family Size | Family Size Share |
|---|---|---|---|---|---|---|---|
| Cereal | 2.737<br>(17.22)** | −0.2879<br>(−15.9[illegible])** | −48.6854<br>(−0.81) | 0.0198<br>(9.52)** | −31.4317<br>(−7.37)** | 0.0022<br>(1.18) | −5.1851<br>(−1.38) |
| Rice | 2.103<br>(12.41) | −0.2145<br>(−11.15)** | −61.094<br>(−0.95) | 0.0196<br>(8.87)** | −38.376<br>(−8.45)** | 0.0024<br>(1.22) | 1.981<br>(0.50) |
| Wheat | 0.6338<br>(6.25)** | −0.0729<br>(−6.33)** | 1.032<br>(0.027) | −0.0001<br>(−0.09) | 7.604<br>(2.80)** | −0.0005<br>(−0.46) | 6.504<br>(−2.72)** |
| Root crops | −0.0184<br>(−0.98) | 0.0026<br>(1.24) | 45.834<br>(6.45)** | 0.0002<br>(0.90) | −1.855<br>(−3.69)** | 0.0010<br>(4.76)** | −2.817<br>(−6.38)** |
| Green vegetables | −0.0987<br>(−2.11)** | 0.138<br>(2.59)** | 71.239<br>(4.01)** | 0.0002<br>(0.28) | 0.6032<br>(0.48) | 0.0003<br>(0.52) | −3.79<br>(−3.43)** |
| Mustard oil | 0.0095<br>(0.39) | 0.0023<br>(0.84) | −1.648<br>(−0.18) | −0.0009<br>(−2.76)** | 0.7054<br>(1.09) | 0.0001<br>(0.37) | −0.3729<br>(−0.66) |
| Vegetable ghee | (−0.0039<br>(−3.10)** | 0.0005<br>(3.38)** | 0.4630<br>(0.96) | −0.00004<br>(−2.44)** | 0.0536<br>(1.57) | 0.00004<br>(2.81)** | −0.417<br>(−1.39) |
| Powdered milk | −0.0041<br>(−0.54) | 0.0005<br>(0.53) | 1.159<br>(0.40) | 0.0001<br>(1.24) | −0.1740<br>(−0.85) | −0.0000<br>(−0.02) | 0.0003<br>(0.001) |
| Milk curds | −0.0432<br>(−1.69)* | 0.0081<br>(2.80)** | −23.138<br>(−2.38)** | −0.0010<br>(−3.00)** | 1.147<br>(1.67)* | 0.0000<br>(0.12) | 1.536<br>(2.55)** |
| Fruits | −0.0461<br>(−0.96) | 0.0091<br>(1.67)* | −36.506<br>(−2.00)** | 0.0004<br>(0.68) | 2.731<br>(2.12)** | −0.0010<br>(−1.71)* | 1.904<br>(1.68)* |
| Sugar | −0.02300<br>(−1.57) | 0.0036<br>(2.19)** | −2.478<br>(−0.45) | −0.0005<br>(−2.76)** | 0.4658<br>(1.19) | 0.0001<br>(0.81) | 0.1034<br>(0.30) |
| Spices | 0.0220<br>(0.91) | 0.0027<br>(1.00) | 3.143<br>(0.34) | −0.0012<br>(−3.76)** | 1.614<br>(2.50)** | −0.8285<br>(−2.95)** | −0.2344<br>(−0.41) |
| Tea | −0.0146<br>(−1.54) | 0.0034<br>(3.18)** | −13.438<br>(−3.74)** | −0.0013<br>(−10.62)** | 1.568<br>(6.18)** | −0.0002<br>(−1.94)* | 0.6308<br>(2.80)** |
| Fish | 0.0744<br>(2.11)** | 0.0007<br>(0.17) | −63.816<br>(−4.76)** | −0.0025<br>(−5.51)** | 3.088<br>(3.26)** | −0.0019<br>(−4.59)** | 3.072<br>(3.69)** |
| Beef, meat, chicken | −0.1607<br>(−5.34)** | 0.0221<br>(6.49)** | −1.165<br>(−0.10) | −0.0010<br>(−2.45)** | 0.9223<br>(1.14) | 0.0008<br>(2.23)** | 0.6751<br>(0.95) |
| Kerosene | 0.0220<br>(1.51) | −0.0004<br>(−0.27) | 1.408<br>(0.26) | 0.0003<br>(1.84)* | 0.1433<br>(0.37) | −0.0005<br>(−2.81)** | −0.1050<br>(−0.31) |
| Electricity | −0.0109<br>(−3.79)** | 0.0017<br>(5.19)** | −2.505<br>(−2.29)** | −0.0004<br>(−9.76)** | 0.5229<br>(6.77)** | −0.0000<br>(−0.50) | 0.0852<br>(1.25) |
| Handloomed cloth | −0.3918<br>(−6.04)** | 0.0499<br>(6.77)** | 79.433<br>(3.23)** | −0.0012<br>(−1.47) | 2.679<br>(1.54) | 0.0019<br>(2.50)** | −2.448<br>(−1.60) |
| Mill-made cloth | −0.1216<br>(−2.40)** | 0.153<br>(2.67)** | 19.772<br>(1.03) | 0.0002<br>(0.24) | −0.5325<br>(−0.39) | 0.0003<br>(0.55) | −0.2987<br>(−0.25) |
| Foreign-made cloth | −0.1101<br>(−1.98)** | 0.0137<br>(2.17)** | 15.160<br>(0.72) | 0.0004<br>(0.60) | −1.140<br>(−0.76) | 0.0005<br>(0.74) | 0.0678<br>(0.05) |
| Old ready-made cloth | 0.0085<br>(1.45) | −0.0008<br>(−1.18) | 0.8911<br>(0.40) | −0.0001<br>(−0.71) | 0.1568<br>(1.00) | 0.0001<br>(1.10) | −0.1839<br>(−1.33) |
| Education | −0.1506<br>(−4.40)** | 0.0178<br>(4.57)** | 21.222<br>(1.63) | 0.0004<br>(0.83) | −0.5476<br>(−0.60) | 0.0021<br>(5.14)** | −1.085<br>(−1.34) |
| Health and medicine | −0.1749<br>(−3.29)** | 0.0257<br>(4.25)** | −5.111<br>(−0.25) | −0.0011<br>(−1.63) | 1.493<br>(1.05) | −0.0012<br>(−1.94)* | 2.398<br>(1.91)* |
| Transportation | −0.0873<br>(−4.04)** | 0.0130<br>(5.29)** | 2.723<br>(0.33) | −0.0016<br>(−5.64)** | 1.550<br>(2.67)** | −0.0001<br>(−0.23) | 0.1535<br>(0.30) |

*(continued)*

## Table 76—Continued

| Commodity | Constant | Log Total Expenditure | Total Expenditure Share | Infrastructure | Infrastructure Share | Family Size | Family Size Share |
|---|---|---|---|---|---|---|---|
| Total consumption of foods | 2.689 | −0.2224 | −174.289 | 0.0088 | −10.20 | −0.0062 | 1.092 |
| | (20.00)** | (−14.57)** | (−3.42)** | (5.00)** | (−2.83)** | (−3.95)** | (0.34) |
| Total consumption of consumer goods | −0.7273 | 0.0933 | 123.814 | −0.0012 | 1.330 | 0.0033 | −2.508 |
| | (−6.94)** | (7.85)** | (3.11)** | (−0.90) | (0.47) | (2.71)** | (−1.01) |
| Total consumption of health, travel and personal services | −0.2877 | 0.0427 | −0.0166 | −0.0032 | 3.521 | −0.1465 | 2.815 |
| | (−4.76)** | (6.22)** | (−0.01) | (−4.10)** | (2.17)** | (−2.08)** | (1.98)* |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: The numbers in parentheses are t-values. Total Expenditure Share = (Expenditure on Commodity Total/Consumption Expenditure of Household). Infrastructure Share = (Infrastructure Index/Total Consumption Expenditures of Household). Family Size Share = (Family Size/Total Consumption Expenditures of Household).

*t-value is significant at the 10 percent level.

**t-value is significant at the 5 percent level.

## Table 77—Expenditure elasticities of goods and services by income quartiles in developed and underdeveloped villages

| | Developed Villages | | | | Underdeveloped Villages | | | |
|---|---|---|---|---|---|---|---|---|
| | Quartile | | | | Quartile | | | |
| Item | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Cereals | 0.84 | 0.94 | 0.52 | 0.36 | 0.89 | 0.95 | 0.95 | 0.79 |
| Field crops | 0.41 | 0.55 | 1.40 | 0.92 | 1.30 | 0.98 | 1.47 | 1.25 |
| Narcotics | 1.58 | 1.23 | 0.52 | 1.37 | 2.72 | 1.56 | 0.91 | 0.49 |
| Sugar | 2.96 | 1.41 | 2.20 | 1.92 | 1.38 | 1.00 | 2.34 | 1.58 |
| Oils and fats | 1.16 | 0.90 | 1.45 | 1.26 | 1.89 | 0.83 | 1.12 | 1.69 |
| Fruits | 2.17 | 1.08 | 0.98 | 1.17 | 1.56 | 1.27 | 1.05 | 1.56 |
| Tea | 1.28 | 0.81 | 1.99 | 0.79 | . . . | . . . | . . . | . . . |
| Fish and livestock | 2.85 | 0.72 | 1.70 | 1.72 | 2.31 | 1.92 | 0.84 | 2.02 |
| Energy and fuel | 0.78 | 1.05 | 0.73 | 0.78 | −0.19 | 0.64 | 0.52 | 0.39 |
| Consumer goods | 2.07 | 1.85 | 0.73 | 0.75 | 2.10 | 1.28 | 1.05 | 1.10 |
| Services | 2.35 | 1.20 | 1.74 | 1.64 | 1.67 | 0.76 | 1.70 | 1.80 |
| Total nonfood | 1.45 | 1.30 | 1.14 | 1.12 | 0.66 | 0.89 | 0.96 | 0.98 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: The ellipses ( . . . ) indicate that average and marginal budget shares for calculation of elasticity are negligible. Quartile 1 is the household group with the lowest expenditure and quartile 4 is the highest. The narcotics included in this data are biri, cigarettes, betel leaf and nuts, tobacco, and jarda.

## Table 78—Distribution of sample households by income quartiles and savings rate groups, 1982

| Income Quartile | Savings Rate<br>Negative or Zero | Low (0-5.5) | Medium (5.5-10) | High (More than 10) | Total |
|---|---|---|---|---|---|
| | (percent) | | | | |
| 1st | 57.32 | 30.57 | 8.28 | 3.82 | 100 |
| 2nd | 42.04 | 27.39 | 11.46 | 19.11 | 100 |
| 3rd | 33.76 | 21.02 | 15.29 | 29.93 | 100 |
| Top | 12.10 | 10.83 | 13.38 | 63.69 | 100 |
| All households | 36.31 | 22.45 | 12.10 | 29.14 | 100 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

## Table 79—Distribution of saving households by landownership and infrastructure groups, 1982

| Landownership Group | Number of Households | | Proportion of Total Households in Group | | Proportion of Positive Savers in Group | |
|---|---|---|---|---|---|---|
| | DV | UNDV | DV | UNDV | DV | UNDV |
| | | | (percent) | | (percent) | |
| Landless | 85 | 106 | 31.4 | 29.7 | 70.6 | 58.5 |
| Land owned | | | | | | |
| Small | 98 | 115 | 36.2 | 32.2 | 58.2 | 56.5 |
| Medium | 66 | 94 | 24.4 | 26.3 | 65.2 | 69.1 |
| Large | 22 | 42 | 8.0 | 11.8 | 81.8 | 71.4 |
| Total | 271 | 357 | 100.0 | 100.0 | 65.7 | 62.2 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: DV is infrastructurally developed villages; UNDV is underdeveloped villages.

## Table 80—Regression results for all households: per capita savings as dependent variable

| Independent Variables and Equations | All Households | Landowning Households | Landless Households |
|---|---|---|---|
| Restricted equation | | | |
| INF | 2.2397<br>(0.227) | 5.1759<br>(0.397) | 0.6096<br>(0.071) |
| INCM | 0.4371<br>(18.206) | 0.4887<br>(16.247) | 0.1293<br>(2.506) |
| $(INCM)^2$ | -1.059E-05<br>(-8.173) | -1.203E-05<br>(-6.905) | 0.3708<br>(0.267) |
| $(INCM)^3$ | 1.3861E-09<br>(14.327) | 1.230E-09<br>(10.5432) | 4.272E-09<br>(3.235) |
| Constant | -1,072.4116<br>(-10.353) | -1,344.996<br>(-9.558) | -278.517<br>(-2.496) |
| $\bar{R}^2$ | 0.90 | 0.81 | 0.65 |
| Estimated MPS[a] at mean level | 0.405 | 0.463 | 0.203 |
| Fully specified equation | | | |
| INF | 8.694<br>(0.972) | 12.604<br>(1.063) | -4.8125<br>(-0.603) |
| INCM | 0.5261<br>(23.106) | 0.5651<br>(20.319) | 0.1595<br>(3.254) |
| $(INCM)^2$ | -7.102E-06<br>(-5.929) | -6.943E-06<br>(-5.110) | 1.5523<br>(1.190) |
| $(INCM)^3$ | 1.262E-09<br>(14.655) | 1.169E-09<br>(11.407) | 4.287E-09<br>(3.464) |
| CRDTI | -4.8586<br>(-3.265) | -4 7834<br>(-2.740) | -8.491<br>(-5.890) |
| EDCN | -4.6493<br>(-0.684) | -3.6656<br>(-0.447) | -15.592<br>(-1.601) |
| WRKR | 62.8031<br>(2.108) | 46.845<br>(1.232) | 33.714<br>(1.259) |
| HYV | -237.536<br>(-3.853) | -327.348<br>(-3.890) | . . . |
| SCPT | 0.0246<br>(1.580) | 0.0332<br>(1.846) | 0.0703<br>(1.702) |
| LAND | -9.352<br>(-10.960) | -10.574<br>(-9.913) | . . . |
| Constant | -1,079.337<br>(-9.934) | -1,053.29<br>(6.929) | -290.212<br>(-2.448) |
| $\bar{R}^2$ | 0.84 | 0.85 | 0.70 |
| Estimated MPS[a] at mean level | 0.52 | 0.561 | 0.234 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: The numbers in parentheses are t-values.

[a] MPS is the share of incremental income that is saved. For example, if income increases by one taka, MPS of 0.4 means that 40 percent of that one taka is saved.

## Table 81—Regression results for all but 10 extreme households: per capita savings as dependent variable

| Independent Variables and Equations | All Households | Landowning Households | Landless Households |
|---|---|---|---|
| Restricted equation | | | |
| INF | 7.0674<br>(0.832) | 10.6981<br>(0.944) | 0.6097<br>(0.071) |
| INCM | 0.2253<br>(9.050) | 0.2553<br>(7.751) | 0.1293<br>(2.506) |
| $(INCM)^2$ | −1.054E-06<br>(−0.202) | −1.031E-06<br>(0.021) | 1.823E-06<br>(0.321) |
| $(INCM)^3$ | 1.8997E-09<br>(11.449) | 1.7826E-09<br>(8.729) | 4.272E-09<br>(3.231) |
| Constant | −617.744<br>(−6.439) | −790.136<br>(−5.904) | −278.51<br>(−2.496) |
| $\bar{R}^2$ | 0.81 | 0.82 | 0.65 |
| Estimated MPS[a] at mean level | 0.284 | 0.323 | 0.203 |
| Fully specified equation | | | |
| INF | 9.6254<br>(1.209) | 12.608<br>(1.183) | −4.8125<br>(−0.603) |
| INCM | 0.327<br>(13.006) | 0.3499<br>(10.783) | 0.1595<br>(3.254) |
| $(INCM)^2$ | −1.004E-06<br>(−0.421) | −1.120E-06<br>(−0.314) | −1.10E-06<br>(−0.04) |
| $(INCM)^3$ | 1.959E-09<br>(12.063) | 1.877E-09<br>(9.444) | 4.287E-09<br>(3.464) |
| CRDTI | −3.9366<br>(−2.940) | −3.8156<br>(−2.405) | −8.490<br>(−5.890) |
| EDCN | −0.256<br>(−0.042) | 0.786<br>(0.107) | −15.592<br>(−1.609) |
| WRKR | 64.640<br>(2.513) | 61.867<br>(1.797) | 33.714<br>(1.259) |
| HYV | −139.206<br>(−2.513) | −204.523<br>(−2.675) | . . . |
| SCPT | 0.0719<br>(4.746) | 0.076<br>(4.305) | 0.070<br>(1.699) |
| LAND | −5.9368<br>(−7.267) | −6.769<br>(−6.464) | . . . |
| Constant | −730.539<br>(−7.228) | −717.65<br>(−5.052) | −290.212<br>(−2.45) |
| $\bar{R}^2$ | 0.85 | 0.85 | 0.72 |
| Estimated MPS[a] at mean level | 0.381 | 0.422 | 0.234 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Note: The numbers in parentheses are t-values.

[a] MPS is the share of incremental income that is saved. For example, if income increases by one taka, MPS of 0.4 means that 40 percent of that one taka is saved.

## Table 82—Importance of rice milling by infrastructure and landownership, milled rice as percent of total rice, 1982

| Landownership Group | Milled Rice as a Share of the Total Amount Consumed | | |
|---|---|---|---|
| | Underdeveloped Villages | Developed Villages | Difference[a] |
| | | (percent) | |
| Landless | 40.3 | 73.6 | 33.3 |
| Land owned | | | |
| Small | 33.0 | 55.6 | 22.6 |
| Medium | 35.5 | 59.4 | 23.9 |
| Large | 36.2 | 56.7 | 20.5 |
| All households | 35.8 | 60.6 | 24.8 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

[a] Difference is the percentage for the underdeveloped villages subtracted from that for the developed villages.

## Table 83—Effect of infrastructure on amount of paddy marketed per household, estimated by the Tobit Method

| Variable | All Households | | Underdeveloped Villages | | Developed Villages | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (1) | (2) | (1) | (2) |
| Constant | −25.03<br>(−0.95) | 7.26<br>(1.28) | 3.78<br>(0.13) | 21.73<br>(1.74)* | −239.6<br>(−1.70) | 23.75<br>(2.19)** |
| Paddy output | 0.544<br>(16.59)*** | 0.544<br>(16.53)*** | 0.413<br>(8.75)*** | 0.412<br>(8.72)*** | 0.641<br>(12.44) | 0.646<br>(12.40) |
| Square of paddy output | −0.000056<br>(−0.90) | −0.000063<br>(−1.02) | 0.000025<br>(2.80)*** | 0.00024<br>(2.74)** | −0.00033<br>(−3.05) | −0.00035<br>(−3.06)*** |
| Household size | −1.41<br>(−3.02)*** | −1.47<br>(−3.18)*** | −0.115<br>(−0.18) | −0.156<br>(−0.25) | −2.38<br>(−3.32)*** | −2.42<br>(−3.42)*** |
| Price of paddy | 0.204<br>(1.30) | . . . | 0.118<br>(0.72) | . . . | 1.604<br>(1.87)* | . . . |
| Infrastructure underdevelopment index | −1.75<br>(−3.63)*** | −1.83<br>(−4.57)*** | −3.384<br>(−2.98)*** | −3.343<br>(−2.99)*** | −1.908<br>(−0.63) | −6.232<br>(−2.63)*** |
| $\bar{R}^2$ | 0.68 | 0.66 | 0.67 | 0.67 | 0.73 | 0.72 |
| Log-L | −1,756.00 | −1,757.00 | −989.00 | −989.00 | −753.00 | −756.00 |
| Number of cases | 455 | 455 | 260 | 260 | 195 | 195 |

Source: Computed from survey data collected by the International Food Policy Research Institute and the Bangladesh Institute of Development Studies in 1982.

Notes: The dependent variable is the amount of paddy marketed (maund/farm). Figures in parentheses are t-values.

*Significant at the 10 percent level.

**Significant at the 5 percent level.

***Significant at the 1 percent level.

## Table 84—Percent of women practicing family planning in electrified and nonelectrified households, 1985

| | Electrified Villages (Developed) | | | Nonelectrified Villages (Under-developed) | Ratio Between | | |
|---|---|---|---|---|---|---|---|
| Age of Women | Households with Electricity (1) | Households without Electricity (2) | All Households (3) | All Households (4) | (1) and (4) | (2) and (4) | (3) and (4) |
| | | (percent) | | (percent) | | | |
| 10–19 | 50.0 | 40.0 | 45.4 | 14.3 | 3.5 | 2.8 | 3.2 |
| 20–29 | 65.3 | 48.0 | 59.3 | 26.8 | 2.4 | 1.8 | 2.2 |
| 30–39 | 48.1 | 31.3 | 41.7 | 25.4 | 1.9 | 1.2 | 1.7 |
| 40–50 | 29.7 | 7.7 | 22.9 | 3.4 | 8.7 | 2.3 | 6.7 |
| Total | 46.6 | 29.5 | 40.6 | 18.2 | 2.6 | 1.6 | 2.2 |

Source: Nazrul Hoque, "Rural Electrification and Its Impact on Fertility: Evidence from Bangladesh" (Ph.D. dissertation, Pennsylvania State University, 1987).

## Table 85—Industrial growth indices for Bangladesh, 1967/68 and 1981/82

| | 1967/68 | | 1981/82 | |
|---|---|---|---|---|
| Size of Industry | Employment | Value | Employment | Value |
| Large and medium | 100 | 100 | 100 | 100 |
| Small | 100 | 47 | 88 | 39 |
| Cottage | 656 | 35 | 387 | 80 |

Source: A. R. Khan and Mahabub Hossain, *Bangladesh: A Study in Development Strategy* (London: McMillan, 1990).

Note: Large and medium-scale industries are the base.

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Paul Dorosh
Alberto Valdés

December 1990

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# EFFECTS OF EXCHANGE RATE AND TRADE POLICIES ON AGRICULTURE IN PAKISTAN

**Paul Dorosh**
**Alberto Valdés**

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# FOREWORD

This report on Pakistan is one of a series of country studies undertaken by the International Trade and Food Security Program at IFPRI on trade and macroeconomic policies. Other studies in this series include research reports on Colombia, Argentina, Nigeria, Zaire, and the Philippines, and collaborative work with the World Bank on this topic in several other countries in Asia, Africa, and Latin America.

The findings from this research have vividly shown the need to analyze the effects of policy interventions in agriculture in developing countries in an economy-wide framework. There is now an overwhelming body of evidence showing that trade and exchange rate policies have, in most countries, had a far greater impact, generally adverse, on agricultural incentives than policies that are specific to agriculture. Through their influence on incentives vis-à-vis the nonfarm sector, these indirect and usually implicit price interventions influence private investment and labor employment in agriculture and induce substantial income transfers from agriculture to the rest of the economy.

This research report examines the Pakistan experience from the early 1960s until 1987. It attempts to quantify the effects on the agricultural sector of both sectoral policy interventions and the indirect effect of economy-wide trade and macroeconomic policies. The empirical findings are analyzed in a broad policy context, and the authors draw some implications for development strategy in Pakistan.

Just Faaland

Washington, D.C.
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# 1

# SUMMARY

Although price policies play an important role in determining returns to agriculture, trade and macroeconomic policies can also have a large impact on the agricultural sector. By changing the relative prices of importables, exportables, and home goods, trade and exchange rate policies alter the structure of incentives throughout the economy. The indirect effects on agriculture can be especially pronounced, since many major agricultural commodities are internationally tradable goods.

These issues are particularly important for Pakistan, where the share of agriculture in gross domestic product (GDP) remains high, and about half of the labor force is employed in agriculture. Further growth in the agricultural sector is crucial for overall economic development and to improve the welfare of many of the poorest people in Pakistan. Moreover, as the Pakistan government seeks new revenue sources to ease its budgetary problems, increased explicit taxation of the large agricultural sector has become a serious option.

This study, based on a framework devised for an earlier work, attempts to quantify both the "direct effects" of agricultural policy interventions (such as commodity-specific trade taxes, guaranteed producer prices, and input subsidies) and the indirect effects of economy-wide trade and macroeconomic policies (which influence the real exchange rate) on the agricultural sector.

From an examination of the goals and instruments of trade policies in Pakistan, it is evident that, for the most part, import quotas rather than import taxes have determined the structure of protection; the major purpose of tariffs, when these were applied, was to raise revenues. Measures of effective rates of protection (as constructed in other studies) show wide variance across industries, although in general trade policy has had a distinct import substitution bias. The antiexport bias was partially reduced for selected industries by granting export subsidies. Generally, export subsidies went to existing industries with strong lobbies, such as the textile industry. As a result, growth of nontraditional exports suffered.

Implicit import tariffs on the principal importables—manufactured goods, fertilizers, wheat, and vegetable oils (ghee)—were 130 to 220 percent in the 1960s and 40 to 55 percent from the mid-1970s to 1987. Implicit export subsidies—on raw cotton, cotton yarn, cotton textiles, basmati rice, and petroleum—have been 5 percent or less since the mid-1970s. Thus effective exchange rates for imports (equal to the official exchange rate adjusted for implicit import taxes) have consistently been 50 to 60 percent higher than effective exchange rates for exports.

A trade policy bias toward importables leads to an appreciation of the real exchange rate (that is, a decrease in the ratio of the domestic price of traded goods to nontradables). The real exchange rate appreciates because tariffs on imports raise the domestic prices of import goods so that demand shifts toward nontraded goods, raising their prices. Prices of goods for which there is no protection, such as exportables and many agricultural importables, remain unchanged. But relative to the prices of protected imports or nontraded goods, the prices of unprotected traded goods fall.

Regression analysis indicates that the trade policy bias toward importables has resulted in a real exchange rate appreciation of approximately 18 to 20 percent since the mid-1970s. Despite some depreciation of the nominal exchange rate since 1982, quantitative restrictions on imports have remained in place and in 1987 resulted in a high implicit tariff on imports of 47 percent and an appreciation of the real exchange rate of 26 percent. Thus border prices of traded goods were reduced by the same percentage.

Appreciation of the real exchange rate (the negative indirect effect of trade and macroeconomic policies) has reduced and sometimes reversed the protection provided by agricultural trade policies (positive direct effects) for some commodities. During the 1960s, the overvaluation of the rupee, which lowered the border prices of all traded goods, outweighed the protection provided by direct trade policies (calculated using the official exchange rate) for wheat, ordinary rice, and cotton and increased the taxation of basmati rice.

From 1972 to 1987, direct taxation of agricultural exportables (averaging −15 percent) was reinforced by indirect taxation (for a total of −38 percent). In contrast, the average for the direct and total protection of import-competing products was positive, although the indirect effects reduced this protection from 48 percent to 7 percent during 1972-87. However, this positive average for importables masks the difference between high protection of sugar and milk and considerable taxation of wheat and vegetable oil. Estimates of effective protection, which compare value added calculated using border and actual prices, indicate approximately the same patterns of protection as do the nominal measures, which compare border and actual output prices.

A model of the real effects of changes in agricultural prices is introduced, and results of two model simulations are given, with domestic prices of agricultural products determined using (1) border prices measured at the official exchange rate, and (2) border prices with an adjustment in the real exchange rates. The model simulations show that because Pakistan's major agricultural products (wheat, basmati and ordinary rice, cotton, and sugar) were consistently taxed between the 1960s and the early 1980s, production of these crops suffered. Due to the combined effect of trade and exchange rate policies and agricultural price policies, wheat production was 24 percent lower and basmati rice 52 percent lower in the 1983-87 period than they would have been with no government intervention. Without price interventions—either direct or indirect—farm incomes from these five major crops would have been 40 percent higher during the same period.

Transfers out of agriculture due to direct and indirect price policies averaged, for the five major crops, 25 billion rupees (Rs) per year during 1978-87, about 36 percent of agricultural value added. This implicit tax on agriculture was about nine times the actual net subsidies to producers (both budgetary and off-budget) and more than three times public expenditures on research, extension, and infrastructure for agriculture (about Rs 7 billion per year during 1978-87). Thus, the net effect of price- and nonprice-related income transfers for the five major crops is estimated to be a transfer out of agriculture of approximately 25 percent of agricultural GDP during that period.

Government intervention in agricultural markets also had some positive effects. Domestic producer prices of all major agricultural commodities except vegetable oil and fertilizer were less variable than border prices evaluated at either the official or the simulated free-trade equilibrium exchange rate. The large dairy sector greatly benefited from protection from milk imports, and all consumers faced more stable food prices.

Given the inherent limitations of most agricultural supply models, including this one, in capturing fully the interdependence between sectors (arising from investment behavior, labor and capital flows, and other factors), the output response predicted here should be considered very preliminary. Moreover, the model simulations assume no change in public investment in agriculture and rural infrastructure, compared with historical levels. Finally, the simulations in the scenario modeling free trade with and without real exchange rate adjustments are *not* meant to be taken as policy recommendations. They merely reflect the purpose of the study: to assess the effects on agriculture of government macroeconomic and sectoral price interventions, holding other factors (including public investment) constant.

There may be some scope for increasing the direct taxation of agriculture, particularly if indirect taxes on agriculture arising from trade and exchange rate policies are reduced (for example, by reducing import restrictions in the nonagricultural sector). The indirect taxes on agriculture computed in this study are not paid to the government but accrue mostly to other sectors of the economy and to consumers. In theory, it would be possible to levy direct taxes on agriculture in conjunction with changes in trade and exchange rate policies that reduce the indirect taxation of agriculture so that agricultural incomes would be unchanged. In practice, direct taxation of agriculture is made difficult by problems in measuring agricultural incomes, valuation of land, and tax avoidance.

Although this study is not meant to be an analysis of fiscal and trade policy options in Pakistan, it shows that the indirect effects of trade and exchange rate policies on agricultural producer prices are large and have persisted for more than two decades for several major commodities. These indirect effects are too large to be ignored and should be taken into account in the design of future agricultural pricing policy and taxation in Pakistan.

# 2

# INTRODUCTION

Agricultural price policies play an important role in determining prices, but a sectoral policy focus can miss important linkages between economy-wide policies (trade and macroeconomic policies) and the agricultural sector. By changing the relative prices of importables, exportables, and home goods, trade and exchange rate policies have effects far wider than the balance of trade or incomes for exporters and importers. The indirect effects on agriculture can be especially pronounced since many agricultural commodities are traded goods.

These issues are particularly important for Pakistan, a country of 104 million people in 1988, which has enjoyed steady economic growth for nearly three decades. From 1960 to 1988, the growth of real GDP averaged 6.0 percent per year, while agricultural GDP increased an average of 3.7 percent per year. Public investments in irrigation and the introduction of high-yielding varieties (HYVs) of wheat, rice, and cotton were major factors underlying the growth in agricultural output. Though the share of agriculture in GDP fell as the country's economy developed, agricultural value added still accounted for 23 percent of GDP in 1988 (down from 46 percent in 1960) (Table 1). Moreover, the share of the labor force employed in agriculture did not decline as precipitously, so that agriculture still employs more than half of the labor force.

Most of the major agricultural commodities in Pakistan are tradable goods. Wheat, a major staple food, accounted for about 20 percent of agricultural value added in 1987 (Table 2), with wheat imports supplying about 6 percent of total domestic availability from 1983 to 1987. Raw cotton, cotton yarn, and cotton cloth are Pakistan's leading exports; together they accounted for 35 percent of export earnings in 1987. Basmati rice (a high-valued aromatic rice) and other rice are important food staples; rice exports represented 8 percent of total export earnings in 1987. Sugar and milk are neither exported nor imported in large quantities by Pakistan, though both commodities are widely traded internationally. Milk is especially important in Pakistan's rural economy: the value of milk production was equal to 28 percent of agricultural GDP in 1987.

Table 1—Importance of agriculture in Pakistan, selected years

| Year | Share of GDP | Share of Employment | Value of Agricultural Exports | Share of Agricultural Exports in Foreign Exchange Earnings | Share of Agricultural Exports in Total Exports | Value of Agricultural Imports |
|---|---|---|---|---|---|---|
| | (percent) | | (US$ million) | (percent) | | (US$ million) |
| 1959/60 | 45.83 | n.a. | 71 | 44.38 | 44.38 | 102 |
| 1971/72 | 36.02 | 57.32 | 234 | 39.53 | 39.53 | 93 |
| 1979/80 | 29.57 | 52.67 | 775 | 18.30 | 33.12 | 433 |
| 1987/88 | 23.29 | 51.15 | 1,010 | 16.69 | 28.89 | 674 |

Source: Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).
Note: Exports include rice, hides and skins, raw cotton, and tobacco. n.a. means not available.

## Table 2—Production of the main agricultural commodities and shares of agricultural value added, selected years

| | 1960/61 | | 1970/71 | | 1979/80 | | 1986/87 | |
|---|---|---|---|---|---|---|---|---|
| **Commodity** | **Production** | **Share** | **Production** | **Share** | **Production** | **Share** | **Production** | **Share** |
| | (1,000 metric tons) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | (percent) |
| Wheat | 3,814 | 20.47 | 6,890 | 17.50 | 10,857 | 21.83 | 14,251 | 19.80 |
| Basmati rice | 284 | 1.07 | 371 | 1.00 | 887 | 2.29 | 1,056 | 1.87 |
| Other rice | 730 | 2.63 | 1,848 | 3.56 | 2,329 | 3.01 | 2,464 | 2.27 |
| Cotton | 301 | 3.26 | 707 | 5.10 | 728 | 4.33 | 1,327 | 4.26 |
| Milk | 6,410 | 39.80 | 7,800 | 30.66 | 9,075 | 29.53 | 12,198 | 27.97 |
| Sugarcane | 11,641 | 7.85 | 19,963 | 7.51 | 23,498 | 7.09 | 29,793 | 6.10 |

Source: Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).
Note: The percentages indicate the share of a commodity's production in agricultural value added.

Further growth in the agricultural sector is crucial for overall economic development and to improve the welfare of many of the poorest groups in Pakistan. Yet as the Pakistan government seeks new revenue sources to ease its budgetary problems, increased explicit taxation of the large agricultural sector has become a serious option. While this study is not meant as an analysis of fiscal policy, the actual level of indirect taxation of agriculture through appreciation of the real exchange rate should be considered an extremely relevant element for the policy debate.

This study examines the effects of trade and exchange rate policies on domestic relative prices and agricultural output, consumption, and income transfers in Pakistan. This is a first step toward analyzing the effects of agricultural and economy-wide policies on agricultural growth and rural income. Trade taxes and restrictions on agricultural goods directly affect the prices of these goods. What is less obvious is that import taxes and tariffs designed to protect other sectors of the economy have an effect on the equilibrium real exchange rate and thus affect the prices of all traded goods in the economy, including agricultural goods.

In Pakistan, the large depreciation of the rupee from Rs 9.90 to more than Rs 17.00 per US$1.00 between 1981 and 1987 and the absence of a sizable black market foreign exchange premium have led many observers to conclude that Pakistan's real exchange rate is at or near equilibrium. To the extent that other macroeconomic and trade policies, levels of capital inflow, and world market conditions are unchanged, this observation may be correct. In this report, however, it is argued that the removal of trade taxes and quantitative restrictions would result in a further depreciation of the real exchange rate; thus these trade restrictions (which for the most part result in protection of domestic industry) result in lower domestic prices for other traded goods and, in particular, for all exportables and for most agricultural commodities.

In addressing these issues, this study follows the framework of Krueger, Schiff, and Valdés (1988), and Valdés, Hurtado, and Muchnik (1989) in its approach to analyzing the effects of agricultural price policies (direct effects) and trade and exchange rate policies (indirect effects) on agriculture. Nabi, Hamid, and Nasim (1987) first applied the approach of Krueger, Schiff, and Valdés to Pakistan, and their work provides a valuable foundation for the empirical analysis. This study extends their work in several areas.

In estimating the levels of overall protection, price indices are used to construct a series of implicit import tariffs and export subsidies closer to Carlos Diaz-Alejandro's (1982) method of estimating the trade bias than to Sjaastad's (1980) approach, which estimates the uniform equivalent tariff used in several recent studies. Equilibrium real exchange rates are calculated using a reduced form real exchange rate regression, and these rates are then compared with results from calculating equilibrium exchange rates based on export supply and import demand elasticities and from the purchasing power parity approach.

The commodity coverage has also been extended in this study to include 12 subsectors of agriculture in Pakistan. Finally, the real effects of price policy are modeled in a more detailed manner. Prices of nontraded agricultural goods (such as pulses, meat, sorghum, and millet) are determined endogenously. The extent and direction of trade (imports, exports, or no trade) of other goods are also determined endogenously. Income effects on demand and world prices of basmati rice are incorporated in the analysis.

This report is structured into nine chapters. First, the goals and instruments of trade policy in Pakistan are examined in Chapter 3. This chapter is based on a background paper prepared for this project by Kemal (1988). Effects of trade policies in terms of effective rates of protection for broad categories of industry are also discussed. Chapter 4 focuses on the nominal exchange rate and trade policies in Pakistan and presents measures of overall trade bias (implicit import tariffs and export taxes) and effective exchange rates for imports and exports. Chapter 5 examines historical movements in Pakistan's real exchange rate. Determinants of the real exchange rate are discussed with particular attention paid to the influence of trade policies. Results of a regression analysis are used to construct a time series of equilibrium real exchange rates and the results compared with estimates using the elasticities approach and simple purchasing power parity. Chapter 6 presents calculations of nominal and effective rates of protection for agricultural commodities in Pakistan (the direct trade effects) and compares these with measures of the total effective rates of protection that incorporate the total effects of trade and exchange rate policies on output prices and value added.

In Chapter 7, a model of the effects of changes in prices on agricultural production, consumption, and trade is introduced. Results of two model simulations (free trade in agricultural products and free trade with an adjustment in the real exchange rate) are presented in Chapter 8. This section also includes estimates of the total net income transfers from agriculture due to exchange rate, trade, and pricing policies. Chapter 9 contains the conclusions of the study.

Details on the methodology used to estimate the border prices of agricultural commodities and the price indices for nonagricultural goods are presented in Appendixes 2 and 3 respectively. These appendixes, which supplement Chapter 4, calculate the nominal and effective rates of protection of major crops. Appendix 4 presents the results from a regression on the demand for basmati rice and Appendix 5 presents additional results of the simulations.

# 3

# TRADE POLICY IN PAKISTAN

Trade policy in Pakistan has been designed to achieve three sometimes conflicting objectives: to contain the trade deficit within manageable limits, to ensure adequate availability of essential goods, and to direct investment and production to the sectors that accord with national priorities.[1] In attempting to achieve the first objective (limiting the trade deficit), Pakistani governments have relied more on restriction of imports than on promotion of exports. The objective of providing adequate supplies of essential goods has been implemented by allocating import licenses, lowering import duties, and restricting exports of these goods. However, trade policy has failed to meet the third objective. Instead, the structure of protection resulting from trade policy discriminates against essential agricultural goods, while favoring certain nonessential manufactured goods.

In this chapter the objectives, instruments, and effects of trade policy in Pakistan are summarized. First, the history of Pakistan's trade policy is briefly described. Then effective rates of protection for agriculture and manufacturing industries are reported along with effective exchange rates for major importable and exportable subsectors. Finally, the interrelationship between policy objectives, policy instruments, and the results is examined.

## An Historical Overview

### Increasing Government Controls on Trade: 1952-59

Although Pakistan chose not to devalue the rupee in 1949 along with other countries in the sterling area, the country was able until 1952 to pursue a liberal import policy because the Korean war commodity boom resulted in a large increase in demand for Pakistan's major export commodities, cotton and jute. Under the Open General Licensing (OGL) System, import licenses could be obtained to import any product.

After the Korean war, however, demand for Pakistani products slumped, and foreign exchange earnings declined sharply. The government resorted to import controls but delayed the decision to devalue the rupee until 1956. Import licenses were awarded for imports of capital and intermediate goods to those who had obtained sanctions from the government for setting up industries. Import licenses also were distributed to "category holders" (traders who had imported under the OGL system) in the proportion of their imports in 1951/52. The latter licenses were used mainly for consumer goods. Since, at the prevailing prices, the demand for both consumer goods and intermediate goods far exceeded their supplies, a black market in licenses developed on a massive scale.

At the same time, cotton and jute exports were subjected to export duties, and there was a ban on exports of most other agricultural goods. Inadequate price incentives contributed to a decline in the real value of total exports from US$336 million in 1952/53 to US$95 million in 1958/59 (both in 1960 dollars).

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[1] This chapter is based on a background working paper (Kemal 1988) written for this project.

### Beginnings of Liberalization through Multiple Exchange Rates: 1959-72

While various schemes were set up to restrict imports and allocate import licenses, export taxes were gradually reduced and eventually eliminated, and exports were encouraged through various incentives. Most important was the export bonus scheme, introduced in 1959, under which exporters of manufactured products were awarded export bonus vouchers at different rates (different percentages of f.o.b. values) depending on the stage of processing. These bonus vouchers could then be used to purchase otherwise restricted items from the import "bonus list." Bonus rates were 20 percent for intermediate goods and 30 percent for finished goods in the early 1960s. By the mid-1960s, the bonus rates were raised to 30 and 40 percent of the f.o.b. value.

The bonus export scheme brought about an effective devaluation of the exchange rate for exports receiving bonus vouchers and for imports purchased with bonus vouchers. The landed cost of some imported products (equal to the c.i.f. value plus the value of vouchers plus import taxes) reached four times the c.i.f. value.

Increased availability of foreign exchange through foreign aid and a greater willingness to rely on market mechanisms rather than administrative controls led to an easing of quantitative import restrictions during this period. The licensing system in place at the start of this period created substantial profits (economic rents) for both industrial and commercial license holders because demand for imports far exceeded the supply limited by licenses. Domestic prices of imported goods rose substantially above the cost of imports at the point of entry (Alamgir 1968; Pal 1964).

The OGL system was reintroduced in 1961 with the hope that it would break the monopoly on imports held by "category holders" (established traders). However, because total imports remained constrained and the share of licenses purchased by new importers was less than 10 percent of total imports, substantial profits for importers were only slightly less concentrated than under the old system (Naqvi 1964).

Later, in 1964, a "free list" of goods that could be imported without an import license was introduced, but after the 1965 war with India the number of commodities on the free list was drastically reduced.

### Postdevaluation Period: 1972-76

By 1971 bonus vouchers issued against exports were as high as 35 percent of the export proceeds, and goods imported under bonus voucher schemes accounted for almost 40 percent of total imports. The bonus voucher scheme was finally abolished when the rupee was devalued by 131 percent in May 1972 from Rs 4.76 to US$1.00 to Rs 11.00 to US$1.00. (Subsequently, when the dollar was devalued against all other currencies, the new par value of the rupee was fixed at Rs 9.9 to US$1.00 in March 1973.)

Along with the devaluation of the rupee in 1972 and the end of the bonus export scheme, there were other major changes in import and export policies. Import licensing was simplified; all the permissible imports were placed on either the free list (which now consisted of goods that could be imported from any source once an import license was obtained) and the "tied list" (which consisted of goods that could be imported from specified countries or by the public sector only). Goods not on either list were banned. Import duties were also reduced on intermediate and capital goods. However, imports of consumer goods, especially certain luxury items, were either banned or taxed at high rates.

All export subsidies except tax rebates and export financing were withdrawn. Instead export duties were imposed on a number of products including raw cotton,

cotton yarn, and cotton fabrics. Later in the period, the reduction and finally the elimination of export duties on various products helped to unify the exchange rate for exports.

### Renewal of Balance-of-Trade Problems: 1978-82

Pakistan maintained a constant nominal exchange rate throughout the 1970s, while domestic inflation exceeded world price inflation and the rupee appreciated in real terms. Instead of devaluation of the rupee, the government resorted to export subsidies and quantitative restrictions on imports to manage the balance of trade. Although the number of products on the free list changed little, licensing procedures were tightened. Different duty rates were imposed for commercial and industrial users, and the Raw Material Replenishment Scheme (RMR) was introduced to provide exporters with access to raw materials, including some that were otherwise banned.

Subsidies on selected, mostly traditional exports also were provided through compensatory rebates. The rebates were provided on a number of products at rates ranging from 7.5 to 12.5 percent of f.o.b. value. The rebates were justified on the basis that exporters were allowed tax withdrawals on imported intermediate inputs, but they were not being compensated for duties on capital equipment, higher construction costs, and higher prices of other inputs that are import substitutes. However, the differences in compensatory rebates across commodities did not correspond to the weight of imported (or import substitute) inputs in value of output.

### Managed Float of the Rupee: 1982-88

In January 1982, the rupee was delinked from the dollar and the Pakistani government adopted a managed float exchange rate policy. Along with the gradual depreciation of the rupee came a liberalization of imports. Import bans were lifted from 122 products in 1983, and in place of lists specifying which goods could be imported, a "negative list" (of banned imports) was introduced. A tied list of goods that could be imported only from specified countries or by specified users (the public sector) was also created. In 1987/88, 124 products and in 1988/89, 162 products were removed from the negative list.

In 1988/89, the negative list consisted of 1) items banned for religious or security reasons, 2) luxury consumer goods, and 3) items banned to protect selected industries. It should be noted that most of the items banned to protect domestic industries were already subject to prohibitive import duties so that the ban did not constitute an increase in industrial protection.

## The Structure of Protection

Trade policy in Pakistan has had a distinct bias toward protecting manufactured goods in the domestic market and promoting them through export subsidies in external markets. Imports of manufactured goods have been restricted through tariffs, quotas, and bans, and exports of manufactured goods have been subsidized through various export promotion schemes. But exports of some agricultural goods (such as cotton and rice) have at times been explicitly taxed, while exports of other goods (such as wheat) have been banned.[2]

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[2] Given Pakistan's monopoly on exports of basmati rice, an argument can be made for an optional export tax to maximize the value of exports.

A number of studies have been done in Pakistan to determine effective rates of protection for manufacturing industries. Soligo and Stern (1965) measured effective rates of protection for 1963/64, but their estimates overstated true effective rates of protection for some industries for which tariffs were redundant. For certain other industries, for which quantitative restrictions were binding (so that domestic prices were higher than world prices adjusted for actual tariffs), their estimates of effective rates of protection were too low.

Lewis and Guisinger (1969) included the effects of quantitative restrictions in their calculations of effective rates of protection for 1963/64 by using comparisons of actual domestic and world prices instead of tariff rate schedules. Subsequent studies by Kemal (1978) for Punjab province alone in 1968/69 and Naqvi and Kemal (1983b) also used comparisons of actual prices in their estimates.

Table 3 presents the effective rates of protection for broad industrial categories from the Lewis and Guisinger (1969), Kemal (1978), and Naqvi and Kemal (1983b) studies. The studies are not strictly comparable because Lewis and Guisinger (1968) used aggregated input-output table data and the other two studies used disaggregated survey data from the Census of Manufacturing Industries (Kemal 1978) or their own survey (Naqvi and Kemal 1983b). The effective rates of protection shown therefore are only suggestive of the actual trends.

The estimates of average effective rates of protection in Table 3 show a sharp decline from 271 percent in 1963/64 to 66 percent in 1980/81. However, at least a part of the fall in protection rates is illusory because the protection rates in 1963/64 and 1968/69 are overstated, since no correction was made for the overvaluation of the exchange rate in the 1960s. If it is assumed that the equilibrium exchange rate was 50 percent higher than the official rate in 1963/64,[3] the corrected average effective rate of protection in 1963/64 would be about 150 percent. A similar adjustment for 1968/69 would yield average effective rates of protection not very different from those of 1980/81. This suggests that protection rates in the early sixties were significantly higher than those in the late sixties or early eighties.

The structure of protection has also changed over time. In the late 1960s, effective rates of protection were generally highest for finished goods, somewhat lower for intermediate goods, and lowest for capital goods. In 1980/81 no such cascading structure is found. Instead the average effective rate of protection on intermediate goods is much higher than that for capital or finished goods. For example, in 1980/81, cotton yarn was subsidized both through export subsidies on output and export duties on the major input (raw cotton). Similarly, leather and leather goods were subsidized, while hides and skins exports were taxed. Other intermediate inputs such as polyvinyl resins, synthetic fibers, synthetic yarn, and basic metal products were subject to high import duties. High import duties on intermediate goods also led to relatively lower effective rates of protection on finished products.

On average, there is an increase in the protection provided to capital goods between 1968/69 and 1980/81. However, the higher average effective rate of protection for capital goods in the 1960s is essentially due to a higher average effective rate of protection for industries producing construction materials. The average effective rate of protection in 1980/81 for capital goods apart from construction materials is only 10 percent.

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[3] Pakistan had a multiple exchange rate system in the mid-1960s that included import taxes and export subsidies. As will be shown later, the effective exchange rate for exports in 1963 was 56 percent greater than the official exchange rate. The 50 percent figure assumed in the text is an approximation of the above figure.

Table 3—Effective protection rates on manufactured goods as estimated in three studies, selected years

| Type of Goods | 1963/64 | 1968/69 | 1980/81 |
|---|---|---|---|
| | | (percent) | |
| Finished goods | 883 | 179 | 26 |
| Intermediate goods | 88 | 61 | 235 |
| Capital goods | 155 | 58 | 69 |
| Total | 271 | 125 | 66 |

Sources: 1963/64: S. R. Lewis and S. Guisinger, "Protection in a Developing Country: Case of Pakistan," *Journal of Political Economy* (November-December 1968). 1968/69: A. R. Kemal, "An Analysis of Industrial Efficiency in Pakistan: 1959/69 to 1969/79" (Ph.D. diss., University of Manchester, Manchester, England, 1978). 1980/81: Sywed N. H. Naqvi and A. R. Kemal, *The Structure of Protection on Pakistan: 1980-81*, vol. 2 (Islamabad: Pakistan Institute of Development Economics, 1983).

As shown in Table 4, the averages mask great variations in effective rates of protection across individual manufacturing activities, and between these and other activities. Since the three studies have varying coverage, there are no estimates available for some activities in one or two of the periods. Effective rates of protection have declined sharply for food, cigarettes, textiles, footwear, chemicals, rubber and plastic products, cement, metal products, and machinery. On the other hand, protection seems to have increased for tea, jute textiles, leather and leather goods, paper and board, matches, rerolled iron and steel, and sports goods.

## Protection in Key Manufacturing Sectors

### Cotton Manufacturing

The cotton manufacturing sector, which comprises cotton gins (which separate seed cotton into cotton lint and cottonseed) and the textile industry (which transforms cotton lint into cotton yarn, cloth, and clothing), is Pakistan's most important industrial sector. Partition and independence separated Pakistan's cotton producers from the bulk of the cotton processing industry located in India. Establishment of a domestic textile industry became a top development priority for Pakistan, and trade policies were designed to protect the new industry by forcing down prices of raw materials (raw cotton) and taxing or banning imports of competing goods.

An overvalued exchange rate and export taxes kept domestic prices of raw cotton exports low in the 1960s, while export subsidies raised the export prices of cotton yarn and textiles. As a result, effective rates of protection for cotton yarn and cotton fabrics were 82 and 213 percent, respectively, in 1963/64 (Table 4).

From 1972/73 to 1976/77 exports of both cotton yarn and raw cotton were taxed. However, yarn production enjoyed protection because the rate of export duty on raw cotton was higher. By 1977/78, yarn was subsidized through compensatory rebates (7.5 percent of the f.o.b. price). These rebates, along with lower domestic prices of raw cotton relative to world market prices, provided very high protection for the spinning industry. The high subsidies enabled the industry to grow despite low export prices on yarn and obsolete technology, which caused the value added at world market prices during 1980/81 to be negative. Subsequently, under a program to balance prices, modernize the industry, replace outmoded equipment, and reduce duties on spinning machinery, the efficiency of the industry was increased. A sharp increase in the world

## Table 4—Effective protection rates on individual products, selected years

| Product | 1963/64 | 1968/69 | 1980/81 |
|---|---|---|---|
| | | (percent) | |
| Dairy products | ... | ... | –343 |
| Canning of fruits and vegetables | ... | ... | –202 |
| Fish and other seafood | ... | ... | –2 |
| Edible oils | –189 | –39 | –43 |
| Sugar | –329 | –1,307 | 40 |
| Tea | –6 | ... | 93 |
| Animal feeds | ... | ... | 0 |
| Cigarettes | ... | ... | 38 |
| Cotton ginning | ... | ... | –9 |
| Cotton yarn | 82 | 173 | –431 |
| Cotton fabric | 213 | | 157 |
| Woolen textiles | ... | 116 | 68 |
| Synthetic textiles | 9,900 | 164 | –3 |
| Jute textiles | 183 | ... | 161 |
| Carpets and rugs | ... | ... | 3 |
| Wearing apparel | 1,900 | ... | 33 |
| Leather and leather goods | 96 | 55 | 2,135 |
| Leather footwear | 59 | 110 | 52 |
| Rubber footwear | | 203 | 53 |
| Paper and board | 144 | ... | 492 |
| Printing and publishing | 16 | ... | –43 |
| Drugs and pharmaceuticals | ... | ... | 18 |
| Cosmetics | ... | ... | 362 |
| Soaps and detergents | 223 | ... | –37 |
| Paints and varnishes | 133 | ... | 23 |
| Fertilizers | 186 | 7 | 32 |
| Pesticides | ... | ... | –40 |
| Chemicals | 113 | 88 | 77 |
| Matches | 9 | ... | –314 |
| Petroleum products | –5 | ... | –6 |
| Tyres and tubes | ... | ... | 159 |
| Rubber manufactures | 525 | ... | 99 |
| Plastic products | 335 | ... | 147 |
| Nonmetallic mineral products | 72 | ... | 83 |
| Cement | 49 | 21 | –3 |
| Iron and steel rerolling | 194 | 111 | 318 |
| Metal products | 270 | ... | 39 |
| Utensils | ... | 334 | 3,251 |
| Agricultural machinery | ... | 42 | –20 |
| Textile machinery | 170 | 83 | 15 |
| Metal working machinery | ... | 113 | 14 |
| Sewing machines | 82 | ... | –766 |
| Electric fans | ... | 96 | 98 |
| Electric bulbs and tubes | ... | ... | 37 |
| Electrical machinery | 72 | ... | 16 |
| Motor vehicles | –2,100 | ... | 49 |
| Cycles | ... | 144 | 28 |
| Surgical instruments | ... | ... | 13 |
| Sports goods | 75 | ... | 392 |

Source: 1963/64: R. Soligo and J. Stern, "Tariff Protection Import Substitution and Investment Efficiency," *Pakistan Development Review* (Summer 1965); 1968/69: A. R. Kemal, "An Analysis of Industrial Efficiency in Pakistan: 1959/69 to 1969/79" (Ph.D. diss., University of Manchester, Manchester, England, 1978). 1980/81: Sywed N. H. Naqvi and A. R. Kemal, *The Structure of Protection in Pakistan: 1980-81*, vol. 2 (Islamabad: Pakistan Institute of Development Economics, 1983).

Note: Negative numbers indicate a tax instead of a subsidy.

price of yarn in the 1980s led Pakistan first to withdraw subsidies on yarn exports and subsequently to impose an export duty of Rs 2.00 per kilogram in order to provide sufficient yarn for local fabric and ancillary industries.

Cotton fabrics enjoyed an effective rate of protection of 157 percent in 1980/81 because of compensatory rebates for yarn and fabrics and a small value-added component in the value of output at world prices. Garment industries also enjoyed protection in 1980/81 but at a lower rate of 33 percent. At present, the garment industry is allowed to import duty-free cloth for exports, but the industry does not receive any subsidies in the form of compensatory rebates. Effective rates of protection for the garment industry may have, therefore, remained roughly constant. The effective rate of protection for fabrics is likely to still be high because the fabric industry now enjoys a lower-than-world-market price on cotton yarn.

### Iron and Steel

Pakistan produces pig iron and rolled and flat products of steel. The Pakistan Steel Factory only began production in the 1980s; prior to that only rolled products in the form of billets were produced in rerolling mills and by the shipbreaking industries.

Billets are the most protected steel activity. Rerolling mills enjoyed an effective rate of protection of 318 percent in 1980/81. Similarly, flat products are also protected although the degree of protection may decline following reductions in duties on imports of these goods in recent years. In 1980/81, except for utensils and sewing machines, other metal-based industries enjoyed only low levels of protection or were even taxed.

### Chemicals

Pakistan produces various types of industrial chemical compounds manufactured from imported components. At present, the import duty on import substitutes is 80 percent; on noncompetitive chemicals the duty ranges from 0 to 40 percent. In 1980/81 the effective rate of protection on industrial chemicals was 77 percent.

Fertilizers and pesticides are the two main chemicals produced in Pakistan that are used in the agricultural sector. Even though fertilizer prices in the domestic market were no higher than world market prices in 1980/81, the industry enjoyed an effective rate of protection of 40 percent because of subsidized natural gas, a major input in the industry. However, protection of the fertilizer industry up to 1985 was only notional because the industry was assured a fixed return on equity. Higher returns were taxed through surcharges and lower returns enhanced through subsidies.

The pesticide industry was penalized in 1980/81: its effective rate of protection was −40 percent. Although the industry in Pakistan only consists of the mixing of imported basic chemicals, and there were no duties or taxes on the imports of finished pesticides, the basic chemicals were subjected to sales taxes.

## Conclusions

The existing structure of protection in Pakistan is the result of various ad hoc measures initially undertaken by the government to restrict imports, boost exports, and raise revenues. In general, these policies have had a distinct bias toward import substitution—few policies have had an explicit export promotion orientation.

Between the 1960s and 1980s, import policy aimed to restrict luxury and nonessential imported goods and to enable liberal imports of essential consumer goods, intermediate goods, and capital goods. The structure of tariffs was similar, though tariffs did not determine the structure of protection because quotas were the binding constraint. Instead, the major purpose of tariffs was to raise revenues. The import policies thus favored establishment of industries producing luxury and nonessential goods and enabled some inefficient industries to survive because of high domestic prices supported by heavy protection.

In order to compensate for the overvaluation of the rupee, export subsidies have at times been granted to selected industries to boost exports. Generally, the subsidies have gone to existing industries with strong lobbies, such as the textile industry. As a result, growth of nontraditional exports has suffered.

Trade and tariff policies have not been formulated with a view to creating a structure of incentives consistent with a higher rate of growth in the production of tradables. Only in the mid-1980s has the government begun to make a conscious effort to reorient trade and tariff policies toward the realization of a more trade-oriented incentive structure.

## 4

# EFFECTIVE EXCHANGE RATES FOR IMPORTS AND EXPORTS

For most years since its independence in 1947, Pakistan has had a fixed official exchange rate. Until January 1982, the official exchange rate had changed only three times in 35 years—in 1955, 1972, and 1973. Khan (1986) suggests that the constant nominal exchange rate policy in the late 1970s might have been justified by the argument that the short-run costs of a depreciation of the rupee in terms of higher domestic inflation, reduced economic growth, and increased fiscal cost of subsidies on imported goods were likely to outweigh the short-run benefits of higher prices of traded goods (because import demand and export supply were assumed to be inelastic in the short run). Beginning in 1982, the government adopted an adjustable-peg exchange rate policy, with the rupee pegged to a basket of currencies of major trading partners during part of this period (Pakistan, Ministry of Finance 1987, 44).

For much of the sixties and seventies, Pakistani governments used trade policies rather than changes in nominal exchange rates to help bring about a sustainable current account position. Trade policy instruments included import tariffs, quotas, export taxes, and export bonuses. These trade policies served two other purposes as well. Trade taxes accounted for 38 percent of government revenues between 1976 and 1980, and the protection provided to domestic industry by tariffs and quotas was an integral part of an import substitution development strategy. Because of the sizable effects of trade policies, nominal exchange rates in Pakistan have not reflected the actual cost of foreign exchange to importers and exporters. Import tariffs and surcharges, export taxes, export bonuses, and multiple exchange rate schemes in place at various times have resulted in divergences between the actual costs of foreign exchange for some uses and the official exchange rate. For example, in 1979 a 60 percent tariff was placed on rubber, so that while the official exchange rate was Rs 9.9 to US$1.00, the effective exchange rate for importers of rubber was 15.8 (= 9.9 × 1.6), according to data from Kemal, Burney, and Hameed (1981).

Effective exchange rates can differ by commodity when trade policy instruments are commodity specific. More generally, the effects of trade policies on the actual price of foreign exchange for exports (imports) taken as a whole can be given as the effective exchange rate for exports (imports) defined as

$$E_x = E \cdot (1 - t_x), \tag{1}$$

and

$$E_m = E \cdot (1 + t_m), \tag{2}$$

where

$E$ = the official nominal exchange rate,
$t_x$ = the implicit export tax, and
$t_m$ = the implicit import tariff.

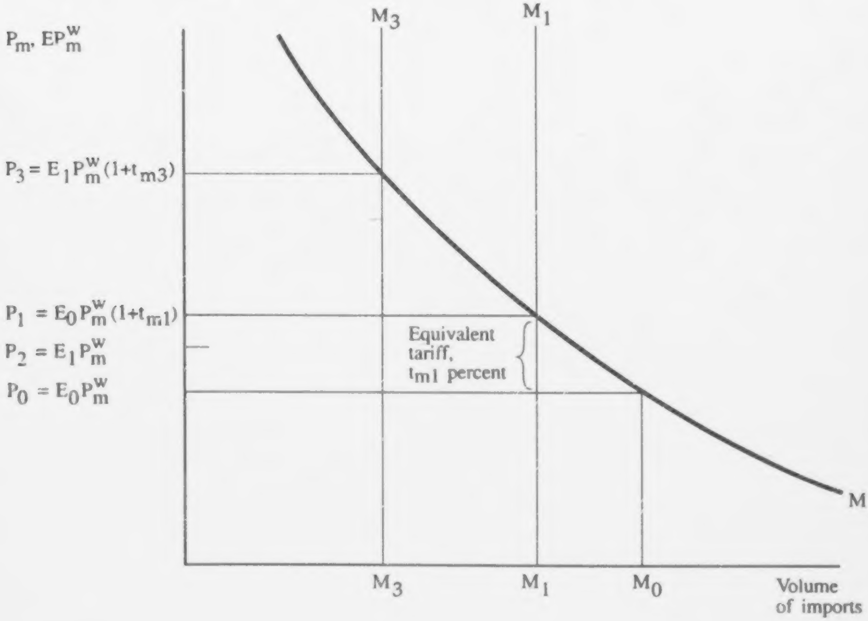
Both $E$, $E_m$, and $E_x$ are expressed in rupees per unit of foreign currency.

Average import tariff or export tax rates calculated using actual tax revenues and trade values may be good measures of $t_m$ and $t_x$ in the absence of import or export quotas. In order to take into account the effects of binding quantitative restrictions, however, the implicit import tariff or export tax, calculated from the ratio of domestic to world prices of the import goods, is a more accurate measure of the direct effect of trade policies. The case of an import tariff is illustrated in Figure 1. With no quota or import tariff, import demand equals $M_0$ when the world price is $P_0$ ($= E_0P^w_m$), where $P^w_m$ is the world price of imports. If imports are limited to $M_1$ by an import quota, then the domestic price of imports rises to $P_1$. The quota on total imports and the domestic price of imports has the same effect as a tariff of $t_{m1}$ percent on imports.

In practice, calculating the implicit import tariff or export tax when quotas are binding and tax rates are not uniform across commodities requires detailed data on world and domestic prices of all traded goods. Estimates of the implicit import tariff and export tax for 1980/81, based on data from Naqvi and Kemal (1983a), are shown in Table 5. The implicit tariffs (taxes) on each category of imports (exports) were aggregated using import (export) value shares as weights in order to calculate the average implicit tariff (export tax).

Two major aspects of Pakistan's trade policy are highlighted. First, quantitative restrictions on imports have had a significant effect on domestic prices of imports. The implicit tariff on imports in 1981 was 54.8 percent, while the average import tax (calculated as total import revenues divided by total value of imports) was only 29.7 percent (Table 6). Thus import taxes captured only 54 percent of the economic rent

**Figure 1—Import quotas and equivalent import tariffs**



## Table 5—Equivalent tariff calculations, 1980/81

| Exported Good | Export Tariff | Nominal Rate of Protection | Imported Good | Import Tariff | Nominal Rate of Protection |
|---|---|---|---|---|---|
| | (Rs million) | (percent) | | (Rs million) | (percent) |
| Raw cotton | 5,203.4 | –24 | Capital goods | | |
| Cotton yarn | 2,048.7 | 52 | Iron, steel bars | 76 | 116 |
| Cotton cloth | 2,389.6 | 61 | Plates, sheets | 1,512 | 116 |
| Ordinary rice | 2,730.6 | –46 | Hoop, strip iron | 26 | 116 |
| Basmati rice | 2,871 | –46 | Rails, track | 58 | 116 |
| Fish | 559.2 | 30 | Iron, steel wire | 50 | 106 |
| Tanned leather | 891.9 | 79 | Tubes, pipes | 281 | 58 |
| Carpets, rugs | 2,242.8 | 0[a] | | | |
| Petrol products | 1,675.2 | 53 | Machinery | | |
| Sports goods | 312.3 | 106 | Power generation | 560 | 12 |
| Raw wool | 80.2 | 0[a] | Agricultural | 1,048 | 14 |
| Others | 8,273.6 | 0[a] | Textile, leather | 739 | 32 |
| | | | Specialized | 828 | 12 |
| Total | 2,9278.5 | 2.7[b] | Electric power | 742 | 12 |
| | | | Motor vehicles | 2,345 | 140 |
| | | | Others | 6,617 | 72[c] |
| | | | Consumer goods | | |
| | | | Wheat | 633 | –41 |
| | | | Other food | 2,983 | 73[c] |
| | | | Petrol products | 1,774 | 53 |
| | | | Medicines, drugs | 936 | 11 |
| | | | Printed matter | 100 | –9 |
| | | | Others | 1,340 | 73[c] |
| | | | Raw materials | | |
| | | | Crude petroleum | 9,840 | 53 |
| | | | Petrol products | 3,585 | 53 |
| | | | Edible oil | 2,625 | –11 |
| | | | Chemicals | 1,212 | 51 |
| | | | Dyeing and tanning materials | 462 | 51 |
| | | | Fertilizers | 3,537 | 0 |
| | | | Other chemicals | 550 | 51 |
| | | | Pig iron | 120 | 116 |
| | | | Ingots | 383 | 116 |
| | | | Other nonferrous materials | 5 | 65 |
| | | | Iron, steel forging | 20 | 116 |
| | | | Copper | 184 | 65 |
| | | | Aluminum | 234 | 65 |
| | | | Others | 8,130 | 72[c] |
| | | | Total | 53,535 | 55.04[b] |

Sources: World Bank, *Pakistan Sixth Plan Progress and Future Prospects*, Report No. 6533-PAK (Washington, D.C.: World Bank, 1988); and Sywed N. H. Naqvi and A. R. Kemal, *The Structure of Protection in Pakistan: 1980-81*, vol. 1 (Islamabad: Pakistan Institute of Development Economics, 1983).

[a] This figure is assumed to equal zero.

[b] This is the weighted average of the nominal rates of protection using trade weights.

[c] "Others" is assumed to equal the average level of protection for the subsector.

## Table 6—Average import taxes and equivalent import tariffs, 1977-87

| Year | Sales Tax on Imports (1) | Import Duties (2) | Iqra (3) | Total Import Tax (4) | Value of Imports (5) | Average Tax (6) | Equivalent Tariff (7) |
|---|---|---|---|---|---|---|---|
| | (Rs million) | | | | | (percent) | |
| 1977 | 1,124 | 4,426 | ... | 5,550 | 23,012 | 24.12 | 52.88 |
| 1978 | 1,226 | 6,034 | ... | 7,852 | 27,815 | 28.23 | 45.60 |
| 1979 | 1,566 | 8,045 | ... | 10,225 | 36,388 | 28.10 | 50.60 |
| 1980 | 2,014 | 9,844 | ... | 12,178 | 46,929 | 25.95 | 55.03 |
| 1981 | 2,537 | 12,126 | ... | 15,913 | 53,544 | 29.72 | 54.82 |
| 1982 | 2,614 | 13,569 | ... | 17,351 | 59,482 | 29.17 | 43.80 |
| 1983 | 2,791 | 17,295 | ... | 22,208 | 68,151 | 32.59 | 42.06 |
| 1984 | 3,699 | 20,901 | ... | 28,099 | 76,707 | 36.63 | 47.29 |
| 1985 | 3,739 | 22,282 | ... | 26,021 | 89,778 | 28.98 | 45.59 |
| 1986 | 3,568 | 24,334 | 4,019 | 31,921 | 90,946 | 35.10 | 51.71 |
| 1987 | 4,564 | 24,649 | 4,397 | 33,610 | 90,077 | 37.31 | 46.99 |

Source: Pakistan, Ministry of Finance, *Economic Survey 1986-87* (Islamabad: Ministry of Finance, 1988) Tables 8.2, 8.4, and 10.3.

Notes: Data for 1987 are preliminary.
Iqra is a surcharge on internationally traded goods.
Total import tax = Sales tax on imports + Import duties + Iqra.
Average tax = Total import tax / Value of imports × 100.
The equivalent tariffs are given in Appendix 1, Table 26.
1977-87 average tax = 30.54; equivalent tariff = 48.76 percent.

accruing to holders of import licenses. Second, the implicit tariffs vary widely by commodity group, and this variance is even more pronounced for effective rates of protection (see the data in Table 4 from Naqvi and Kemal 1983b), which suggests that the quantitative effects may have had unintended effects on the structure of relative incentives to import-competing sectors.

Time series for $t_m$ and $t_x$ were constructed from the 1980/81 estimates from Table 5 and from price indices of import and export goods, using the following equations:

$$1 + t_m(t) = \frac{P^d_m(t)/E(t)P^w_m(t)}{[P^d_m(1981)/E(1981)P^w_m(1981)]} \cdot [1 + t_m(1981)], \qquad (3)$$

$$1 - t_x(t) = \frac{P^d_x(t)/E(t)P^w_x(t)}{[P^d_x(1981)/E(1981)P^w_x(1981)]} \cdot [1 - t_x(1981)], \qquad (4)$$

where the terms in parentheses indicate the year and

$w$ = world prices,
$P^w_m$ = index of the import unit value, and
$P^w_x$ = index of the export unit value,

based on actual quantities and values of Pakistan's trade, and where

$P^d_m$ = index of the domestic price of major imports, and

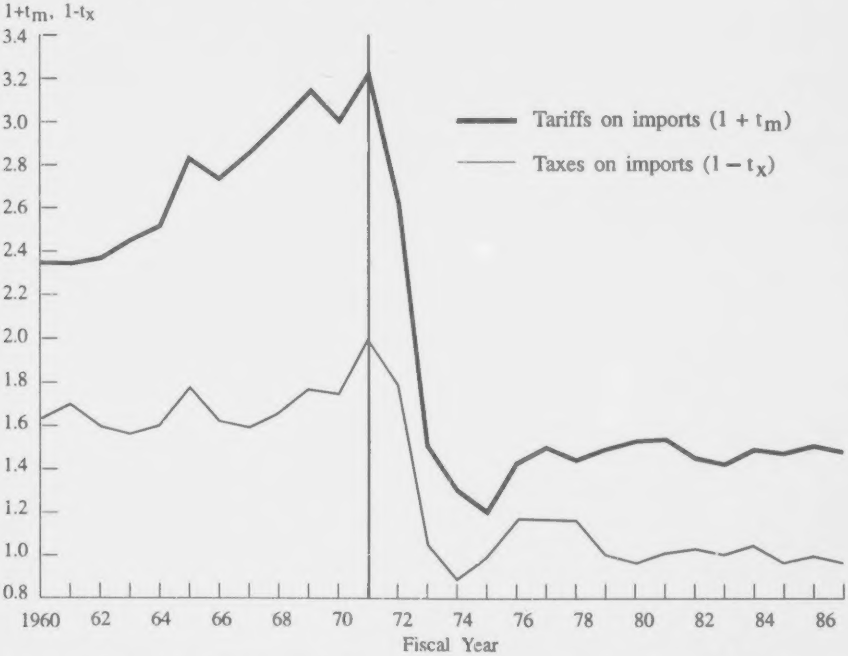
$P_x^d$ = index of the domestic price of major exports.

Two sets of weights were used, for the pre- and post-1971 periods, based on value shares in total imports and exports (weight values and results are given in Appendix 1, Table 26). Appendix 1, Table 27 presents calculations of the implicit import tariff and export tax in 1963/64, which at 110 and –29 percent, respectively, are somewhat below the figures calculated using the price series (152 and –62 percent).

Figure 2 shows the pattern of $1 + t_m$ and $1 - t_x$ over time. From the early 1960s to 1971 the implicit tariff on imports rose from 130 percent to 220 percent. At the same time, the export subsidy (implicit in the system of multiple exchange rates) was between 60 and 80 percent in most years. Thus while the official exchange rate was fixed at Rs 4.78 to US$1.00, the effective exchange rate for imports rose from Rs 11.2 to Rs 15.4 to the dollar, and the effective exchange rate for exports varied from about Rs 7.5 to Rs 9.5 to the dollar (Figure 3 and Appendix 1, Table 26).

The 1972 devaluation of the nominal exchange rate from Rs 4.78 to Rs 11.00 to US$1.00 brought about a simplified exchange rate system, ending the bonus export

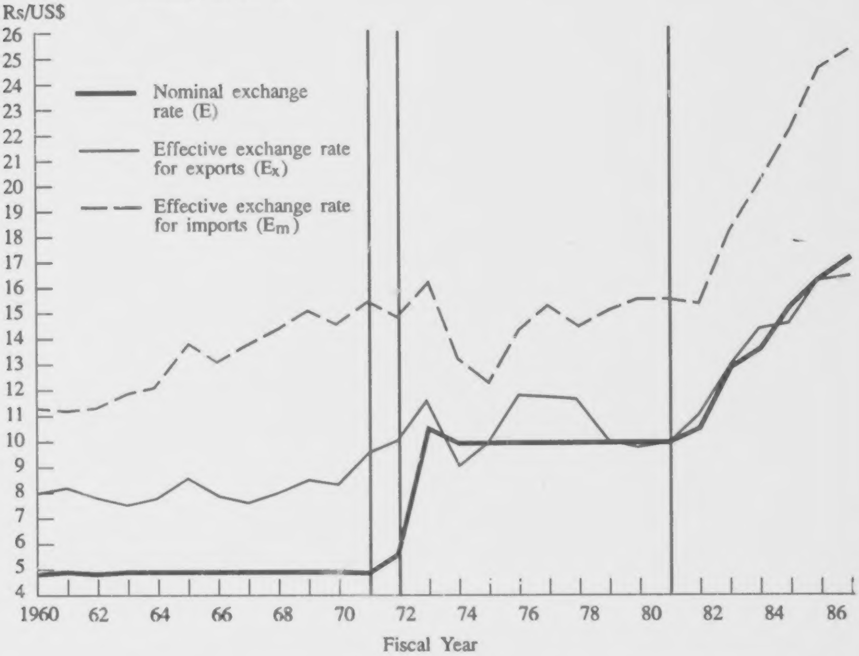
**Figure 2—Overall trade policy bias, 1960-87**



Source: Derived from basic data in Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The vertical line indicates the devaluation and unification of exchange rates. 1971 was the year East Pakistan seceded and Bangladesh was created. Zulfiqar Ali Bhutto governed during 1971-77 and Mohammad Zia ul-Haq during 1977-88.

**Figure 3—Devaluation episodes and evolution of effective exchange rates, 1960-87**



Source: Derived from basic data in Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The vertical lines indicate the nominal devaluations. 1971 was the year East Pakistan seceded and Bangladesh was created. Zulfiqar Ali Bhutto governed during 1971-77 and Mohammad Zia ul-Haq during 1977-88.

scheme and greatly reducing the level of many nominal import tariffs. As a result, the implicit import tariffs and export subsidies were both significantly reduced. The effective exchange rate for imports increased by 5 percent and that for exports by 20 percent[4]—much less than the 121-percent devaluation of the official exchange rate (Figure 3).

The implicit import tariff declined further in 1974 and 1975, but from the mid-1970s to 1987, it remained at about 60 percent. Export taxes and subsidies were also kept small, beginning in the mid-1970s, and did not increase greatly even when the official exchange rate depreciated sharply in the 1970s. As a result, the effective exchange rate for exports approximated the official exchange rate during this period. Unlike the 1972 devaluation, the 73 percent depreciation of the official exchange rate (relative to the dollar) beginning in 1982 resulted in an approximately equal 61 percent depreciation of the effective exchange rate for exports between 1981 and 1987.

---

[4] These changes in effective exchange rates are calculated between fiscal years 1971 and 1973.

The depreciation of the rupee in the 1980s also differed from the devaluation of 1972 in that it was not accompanied by a reduction in implicit import tariffs. This result is somewhat surprising since, all things being equal, the implicit import tariff is reduced by a nominal devaluation because the devaluation increases the world price of imports expressed in rupees, while leaving the domestic price unchanged (assuming the tariff is still binding):

$$(1 + t_m) = P^d_m/EP^w_m. \tag{5}$$

That the implicit tariff did not change significantly (and even increased slightly) indicates that quotas have been reduced (or that demand for the restricted import goods has increased).[5] Returning to Figure 1, with the world price of import goods at $P_0 = E_0P^w_m$, and the quantity of imports restricted to $M_1$ (determined in part by export earnings or foreign exchange reserves), the domestic price of imports rises to $P_1 = E_0P^w_m(1 + t_{m1})$ where $t_{m1}$ is the implicit tariff. With a nominal devaluation, the world price expressed in rupees rises from $P_0 = E_0P^w_m$ to $P_2 = E_1P^w_m$. In this case, if total imports are still restricted to $M_1$, the domestic price of imports remains at $P_1$ and the implicit tariff is measured as $P_1/P_2 = 1 + t_{m2}$. In order for the nominal devaluation not to have an effect on the measured implicit import tariff, the quota on imports must actually be reduced. If foreign exchange earnings or reserves fall so that the import quota is reduced to $M_3$, the import price is raised to $P_3$ and the implicit tariff $(1 + t_{m3})$ increases to $P_3/P_2$.

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[5] A third alternative, that import quotas are a relatively unimportant factor in determining the domestic price of importables in Pakistan, is not consistent with the Naqvi and Kemal (1983a) study.

# 5

# THE REAL EXCHANGE RATE

The previous analysis of effective exchange rates ignored changes in the domestic prices of nontraded goods and in world prices. While the effective exchange rates for imports and exports determine the nominal prices of traded goods in the domestic economy, another measure of price incentives, the real exchange rate (RER), is needed to reflect changes in the domestic price of traded goods relative to the price of home goods.[6]

RER is defined as the relative price of tradables to home goods. In this study, the actual RER is measured as

$$\mathrm{RER} = E \cdot P_T^w / P_h, \tag{6}$$

where E is the nominal exchange rate and $P_T^w$ and $P_h$ are the world price of traded goods and the domestic price of home goods, respectively, and where the numerator represents a policy for the price of tradable goods, ignoring for the moment domestic taxes and quotas on imports and exports. A weighted average of the wholesale price indices of major trading partners of Pakistan is used to represent $P_T^w$:

$$\ln(P_T^w) = \Sigma(w_i \cdot \mathrm{WPI}_i / E_i), \tag{7}$$

where $w_i$, $\mathrm{WPI}_i$, and $E_i$ are the weight, wholesale price index, and exchange rate (expressed in units of a country's own currency per dollar) of country i. The weights used are based on the average share of trade in nonpetroleum products (exports plus imports) of Pakistan's leading trading partners in Pakistan's trade from 1972 to 1986. The weights are as follows: United States, 0.278; Japan, 0.277; United Kingdom, 0.160; West Germany, 0.146; Italy, 0.080; and France, 0.059. These six countries accounted for almost half of Pakistan's trade during this period. An index of consumer prices in Pakistan is used as a proxy for the price of home goods, based on the argument that home goods weigh heavily in this price index.

Effective RER indices for imports ($t_m$) and exports ($t_x$) that take into account trade taxes and quotas are defined as

$$\mathrm{RER}_x = \mathrm{RER} \cdot (1 - t_x), \quad (1981 = 100), \text{ and} \tag{8}$$

$$\mathrm{RER}_m = \mathrm{RER}_x \cdot (1 + t_m)/(1 - t_x). \tag{9}$$

Figure 4 shows the level of the RER indices over time. The large nominal devaluation of the rupee (more than 100 percent) combined with changes in trade policies resulted in a much smaller depreciation of the RER (of about 20 percent) between 1971 and 1973. However, between 1981 and 1987, the 73 percent nominal devaluation of the rupee (relative to the dollar) resulted in a 43 percent depreciation of the effective RER for exports.

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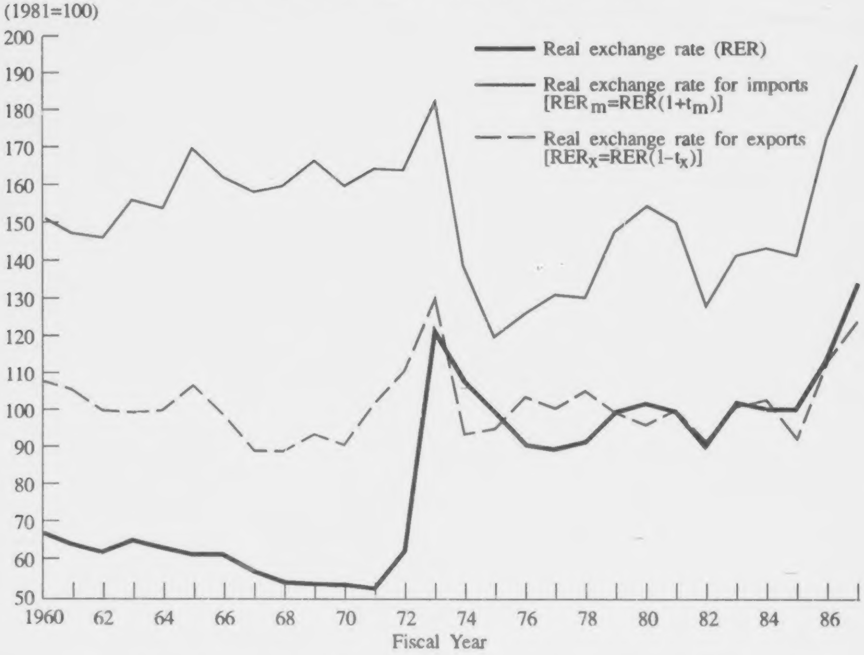
[6] "Home goods" and "nontraded goods" are used interchangeably in the following discussion.

Figure 4—Real effective exchange rate indices, 1960-87



Source: Derived from basic data in Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

## Determinants of the Real Exchange Rate

Even when the nominal exchange rate is fixed for long periods of time, the effective RER can adjust to bring about equilibrium in the traded and home goods markets. These changes in the effective RER come about through changes in world prices and prices of home goods and changes in the implicit import tariff and export tax. Thus factors such as world prices and government trade policies, which influence supply and demand in these markets, affect the effective RER.

Import tariffs and export taxes affect the RER by changing domestic demand and supply for both tradable and nontradable goods.[7] For example, an increase in import tariffs raises the domestic price of importables relative to the domestic prices of exportables and home goods, thereby leading to increased demand for home goods. In order to restore equilibrium in the home goods market, the price of home goods must rise relative to the price of exportables and the new after-tariff price of importables. Thus the RER for exportables appreciates ($P_x/P_h$ decreases). The imposition of an export subsidy has an analogous effect, shifting domestic demand away from exportable goods to importables and home goods.

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[7] The theoretical formulation of the effect of trade policy on the RER is credited to Dornbusch (1974). Sjaastad (1980) and Garcia (1981) give less abstract, though less elegant, presentations of the same concepts.

The extent to which an increase in the domestic price of imports causes an increase in the demand for home goods (and an increase in their price) is measured by the incidence parameter, defined as the negative of the percentage change of the RER for exportables ($P_x/P_h$) for a given percentage change in the domestic price of importables relative to exportables ($P_m/P_x$) (Sjaastad 1980). This incidence parameter, here called omega ($\omega$), is determined in part by the degree of substitutability between home goods and import goods in production and consumption. For example, if home goods are close substitutes for import goods in terms of demand, then an import tariff that raises the price of import goods will cause a large shift in demand toward home goods and a sizable increase in their price.[8]

The external terms of trade (expressed as the ratio of the world price of export goods to the world price of import goods) affects the relative prices of tradables to nontradables in two ways. Like trade policy, there is a direct effect on prices. A worsening of the terms of trade through an increase in the world price of importables, like an increase in the import tariff, raises the domestic price of importables, increases demand for home goods, and leads to an appreciation of the RER for exportables. There is also an income effect. An increased world price for importables reduces the purchasing power of export earnings and reduces real income. The effect on relative demand for tradables and home goods (and on their relative prices) depends on the income elasticities of demand for these goods. In general, a worsening of the terms of trade, that is, a reduction in income, might be expected to cause a decrease in demand for home goods and a depreciation of the RER for exportables. A priori, the net effect on the RER for exportables is indeterminate, although it is usually expected that the income effect will predominate, with a worsening terms of trade requiring a depreciation of the RER to restore external balance (see Edwards 1985).

In the case of Pakistan, workers' remittances (largely from Pakistani workers in the Middle East) are an important part of foreign exchange earnings. Remittances and other private, unrequited transfers are spent partly on home goods, thereby raising their prices and causing an appreciation of the RER. First, a slowing of the increase in workers' remittances and later an absolute decline were factors contributing to the government's decision to depreciate the rupee relative to trading partners' currencies in the 1980s.

Foreign grants and long-term borrowing can also lead to an appreciation of the RER. Because this inflow of foreign exchange accrues to the government rather than to the private sector (as do workers' remittances) the composition of spending on home goods versus tradables is likely to differ, so that the magnitude of the effect on the RER may be different.

The level of government expenditure may also affect the RER by altering the overall pattern of spending in the economy. Typically, government expenditures are concentrated on nontraded goods such as salary payments, various domestic subsidies, and investment in infrastructure. Increasing levels of government expenditure would then

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[8] Bautista (1987) derives an expression for omega as a function of the price elasticities of demand and supply for home goods:

$$x = em - nm/(em - nm + ex - nx),$$

where em and ex are the demand elasticities for home goods with respect to the relative prices of importables and exportables, and nm and nx are the corresponding supply elasticities.

increase demand for nontraded goods relative to traded goods and lead to an appreciation of the RER.[9]

In the above discussion, trade policy and other variables are treated as exogenous, but in the case of Pakistan, some of the explanatory variables are not exogenous but are determined simultaneously with the RER.

In Pakistan, quantitative restrictions on imports have been widely used. Thus changes in the implicit tariff may result even when no changes in tariff rates have occurred, when the size of the quota is varied, or when domestic demand for imports changes. Factors that influence the government to change the import quota, such as foreign exchange earnings and the level of international reserves, and factors that influence domestic demand will thus cause changes in the implicit tariff.

Workers' remittances are largely determined by the price of oil (a major determinant of the level of incomes in the Middle Eastern countries that employ many Pakistani workers), but the RER may influence the amount of income remitted to Pakistan rather than spent or saved abroad. The supply of foreign aid may depend in part on income in developed countries, whereas Pakistan's "demand" for foreign aid may be influenced by its terms of trade, exchange reserves, and ultimately its RER.

## Regression Results

Valdés (1986) summarizes the results of a number of studies that have estimated RER regressions for Latin American countries using either the domestic price ratio of exportables to home goods ($P_x/P_h$) or an RER constructed from wholesale prices of major trading partners as the dependent variable. Because export subsidies and taxes have been significant in Pakistan, the effective RER for exports is used as the dependent variable instead of an average RER index.[10] (See, for example, Valdés, Hurtado, and Muchnik [1989], where an average RER index similar to equation (6) is used without any adjustment for export taxes because export taxes and subsidies were insignificant.)

Expressing the RER as a function of trade policy, terms of trade, and other variables gives

$$\begin{aligned} \log RER_x = {} & c + \beta 1 \cdot LTRPOL + \beta 2 \cdot LTT + \beta 3 \cdot RREMIT \\ & + \beta 4 \cdot RAID + \beta 5 \cdot RGOVT + e, \end{aligned} \tag{10}$$

where

c = the unit constant,

LTRPOL = log of "trade policy", $\log[(1 + t_m)/(1 - t_x)]$,

LTT = log of the terms of trade, $\log(P_x^w/P_m^w)$,

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[9] Valdés (1986) discusses other determinants of the RER that are important in the Latin American context, such as budget deficits, absorption (relative to GNP), and wage policy.

[10] Thus, the dependent variable in the regressions is the logarithm of $RER_x = E(P_T^w/P_h)(1 - t_x)$, where the term $P_T^w$ in the numerator represents a price index of Pakistan's trading partners that includes both exportables and importables. Ideally, one would use the ratio of the domestic price of exportables to the domestic price of home goods ($P_x^d/P_h$) as the real exchange rate for exports. Unfortunately, little disaggregated price data are available with which to construct the price indices, and regressions using the above definition produced unsatisfactory results. A hybrid approach is taken in this study: price indices are used to estimate the equivalent tariff and export tax (Chapter 4), but a more general index of world prices is used [$P_T^w$ in equation (6)] to construct the index of the real exchange rate for exportables.

RREMIT = private transfers in dollars divided by $P_T^W$/real GDP index,

RAID = (sum of aid loans and grants to Pakistan measured in dollars divided by $P_T^W$)/real GDP index, lagged two quarters, and

RGOVT = (government expenditures)/real GDP index.

Tables 7 and 8 present the regression results for both the full sample (1960-87) and for a subsample (1972-87). The first regression in Table 7 is estimated using ordinary least squares for the full sample. A dummy variable (DBANG = 1 for quarters prior to the second quarter of 1972 [1972.2], 0 otherwise) is used to help capture the effects of the secession of East Pakistan in December 1971. In addition, the coefficients of each of the explanatory variables outlined above are allowed to vary between the pre- and post-1971 periods, using dummy variables DTRPOL, DLTT, and DRAID, where

DTRPOL = LTRPOL for 1960.3 to 1972.1,
= 0 for 1972.2 to 1987.1,

DLTT = LTT for 1960.3 to 1972.1,
= 0 for 1972.2 to 1987.1,

DRAID = RAID for 1960.3 to 1972.1, and
= 0 for 1972.2 to 1987.1.

For private transfers (RREMIT), comparable data were not available for most of the pre-1971 period (transfers were very small compared with those of the 1970s), so that no dummy variable for transfers is included.

The coefficient for LTRPOL, equal to $-\omega$ for the post-1971 period, indicates that a 1 percent increase in the ratio of $(1 + t_m)/(1 - t_x)$ will result in a 0.480 percent appreciation of the RER for exports.[11] The coefficients for DRAID and RAID are almost the same in absolute size but opposite in sign, indicating that aid flows were not a significant factor in determining the RER in Pakistan in the pre-1971 period. However, the sum of the coefficients of LTRPOL and DTRPOL, which gives the estimate of $\omega$ for the pre-1971 period, is implausibly high in absolute terms (−1.073), and coefficients on the terms of trade and remittances are insignificant.

As discussed above, some of the explanatory variables, notably the trade policy variables (LTRPOL and DTRPOL) are likely to be endogenously determined along with the RER. To correct for this problem, the equation was reestimated using two-stage

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[11] The coefficient B1 differs slightly from the omega coefficient estimated in studies of other countries for which export taxes or subsidies were relatively small, since the dependent variable, log $RER_x$, is not identical to the real exchange rate used in these studies. For example, Valdés, Hurtado, and Muchnik (1989) estimate a regression of the form

$$\log RER = \alpha 1 + \beta 1 \cdot \log(1 + t_m) + \beta 2 \cdot \log(1 - t_x) + \beta 3 \cdot \log(x),$$

where x represents other variables in the equation. (Note that the term $\beta 2 \cdot \log(1 - t_x)$ was omitted in their regression because $\log(1 - t_x)$ was equal to zero in all years.) The regression used in this study is of the form

$$\log RER_x = A1 + B1 \cdot \log(1 + t_m) - B1 \cdot \log(1 - t_x) + B3 \cdot \log(x).$$

The two regressions can be shown to be equivalent if $\beta 1$ is constrained to equal $-\beta 2-1$.

## Table 7—Real exchange rate regressions, full-period sample, quarterly data, 1960-87

| Regression Number/ Estimation Method | C | DBANG | LTRPOL | DTRPOL | LTT | DLTT | RREMIT (–2) | RAID | DRAID | ρ | Durbin Watson | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. OLS | 2.738* | 0.071 | –0.480* | –0.593* | 0.133 | 0.352 | –62.4 | –264.0* | 264.5* | 0.833* | 2.015 | 0.804 |
|  | (29.717) | (0.453) | (–4.071) | (–2.340) | (1.219) | (1.333) | (–0.929) | (–4.372) | (3.992) | (12.830) |  |  |
| 2. 2SLS | 2.710* | –0.223 | –0.677* | 0.408** | –0.293* | –0.357 | –13.6 | –148.1* | 105.0* | 0.834 | 1.882 | 0.747 |
|  | (30.070) | (–1.623) | (–5.092) | (1.674) | (–2.396) | (–1.419) | (–0.181) | (–2.987) | (1.969) | (12.617) |  |  |
| 3. OLS (first differences) | 0.003 | –0.001 | –0.505* | –0.504** | 0.169 | 0.322 | –208.3 | –165.8* | 193.8* | . . . | 1.249 | 0.386 |
|  | (0.460) | (–0.075) | (–4.045) | (–1.928) | (1.420) | (1.212) | (–1.479) | (–3.016) | (2.983) |  |  |  |

Notes: A sample period of 1960.3 (third quarter 1960) to 1987.1 (first quarter 1987) is used for all regressions. Data for all variables are smoothed using arithmetic moving averages. In Equation 2, LRERX(–1), C, DBANG, and current and lagged values of LTT, DLTT, LPOIL, and LWGDP are used as instrumental variables. The variables are defined as follows:

C = the unit constant,
DBANG = a dummy variable equal to 1 for quarters prior to the second quarter of 1972, 0 otherwise,
LTRPOL = log of $(1 + t_m)/(1 - t_x)$, where $t_m$ is the implicit import tariff and $t_x$ is the export tax,
LTT = log of the terms of trade,
RREMIT = private transfers divided by GDP,
RAID = sum of aid loans and grants to Pakistan divided by Pakistan's GDP,
LPOIL = log of the price of oil, deflated by a wholesale price index for major industrial countries,
LRERX = log of the real exchange rate for exports,
LWGDP = log of the index of the GDP's of major industrial countries,

DTRPOL = DBANG • LTRPOL,
DLTT = DBANG • LTT, and
DRAID = DBANG • RAID,

OLS is ordinary least squares and 2SLS is two-stage least squares.

* Significant at the 95 percent confidence level.
** Significant at the 90 percent confidence level.

## Table 8—Real exchange rate regressions, reduced sample, quarterly data, 1972-87

| Regression Number/ Estimation Method | C | LTRPOL | LTT | RREMIT (–2) | RAID | RGOVT | ρ | Durbin Watson | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| 4. OLS | 2.895*<br>(21.153) | –0.488*<br>(–3.882) | 0.125<br>(1.068) | –197.1**<br>(–1.801) | –295.0*<br>(–4.389) | . . . | 0.866*<br>(12.070) | 1.698 | 0.808 |
| 5. 2SLS | 2.808*<br>(26.284) | –0.410*<br>(–3.248) | 0.072<br>(0.609) | –170.5**<br>(–1.698) | –259.2*<br>(–5.098) | . . . | 0.848*<br>(10.266) | 1.632 | 0.806 |
| 6. OLS (first differences) | 0.005<br>(0.816) | –0.544*<br>–4.254) | 0.180<br>(1.476) | –256.6<br>(–1.651) | –271.4*<br>(–4.094) | . . . | . . . | 1.830 | 0.430 |
| 7. OLS | 3.237<br>(9.616) | –0.496*<br>(–3.947) | 0.132<br>(1.130) | –190.6**<br>(–1.755) | –314.9*<br>(–4.562) | –1.538<br>(–1.122) | 0.861*<br>(11.649) | 1.704 | 0.812 |
| 8. 2SLS | 3.498<br>(10.626) | –0.464*<br>(–3.702) | 0.083<br>(0.711) | –234.8*<br>(–2.467) | –472.3*<br>(–7.482) | –2.117<br>(–1.543) | 0.823*<br>(10.226) | 1.652 | 0.793 |
| 9. OLS (first differences) | 0.006<br>(1.006) | –0.563*<br>(–4.377) | 0.203*<br>(1.646) | –280.7**<br>(–1.794) | –286.4*<br>(–4.248) | –1.788<br>(–1.136) | . . . | 1.839 | 0.443 |

Note: The variables are defined as follows:

C = the unit constant,
LTRPOL = log of $(1 + t_m)/(1 - t_x)$, where $t_m$ is the implicit import tariff and $t_x$ is the export tax,
LTT = log of the terms of trade,
RREMIT = private transfers divided by GDP,
RAID = sum of aid loans and grants to Pakistan divided by Pakistan's GDP, and
RGOVT = government expenditures.

A sample period of 1972.2 (second quarter 1972) to 1987.1 (first quarter 1987) was used for all regressions. Data for all variables are smoothed using arithmetic moving averages. In estimations 5 and 8, LRERX(–1), C, LTT, LTT(–1), LPOIL, LPOIL(–1), LWGDP, and LWGDP(–1) are used as instrumental variables, where LRERX is the log of the real exchange rate for exports, LPOIL is the log of the price of oil deflated by a wholesale price index for major industrial countries, and LWGDP is the log of the index of the GDP's of major industrial countries. OLS is ordinary least squares and 2SLS is two-stage least squares.

* Significant at the 95 percent confidence level.
** Significant at the 90 percent confidence level.

least squares with current and lagged values of an index of national income in developed countries and the deflated dollar price of oil as identifying instrumental variables (regression 2). Current and lagged values of the terms of trade (LTT and DLTT) were also used as instruments. Finally, because of autocorrelation of the residuals, the lagged value of the dependent variable (the RER for exports) was also used as an instrument. The resulting estimates for omega in the pre- and post-1971 periods, −0.677 and −0.269 (= −0.677 + 0.408), are more plausible than the results of regression 1. A positive relationship between the external terms of trade and the RER for exports is also found in both periods.

Results of a regression using the first differences (the arithmetic differences between the current and lagged values) of all variables to correct for the problem of the autocorrelation of the residuals (regression 3) were similar to those of the OLS estimation.

Table 8 presents results of regressions from a reduced sample covering only the post-1971 period. Regressions 4, 5, and 6 correspond to regressions 1, 2, and 3 for the full sample period. Results of all three regressions are similar, with estimates of omega ranging from −0.410 (regression 5) to −0.544 (regression 6). In all three regressions, the coefficient on the terms of trade is insignificant and coefficients on remittances and foreign aid flows are of the expected signs and similar magnitudes. Three other regressions (7, 8, and 9) include the ratio of government expenditures to GDP as an explanatory variable. In each of the regressions, the coefficient on RGOVT has the expected sign but is not statistically significant. In regression 9, the coefficient on the terms of trade (LTT) is positive and statistically significant; values for the estimates of the other coefficients are similar to those in regressions 4, 5, and 6.

Overall, the regressions give similar estimates for the omega coefficient, ranging from −0.410 to −0.677 for the post-1971 period. All of the estimates are biased toward −1, because the logarithm of $(1 - t_x)$ is a component of the numerator of the dependent variable LRERX and LTRPOL, so estimates at the lower end of the range may be closer to the true value of omega. Parameter estimates from regression 4, estimated using two-stage least squares for the post-1971 sample period, are used in the following calculations and the model simulations.

The high values for the autocorrelation coefficient (RHO) in all regressions not estimated using the first differences of the variables indicate that errors unexplained by the included variables have persistent effects. Slowness of the RER to adjust to changes in the explanatory variables and other shocks may be one explanation. One quarter is probably too short a period of time for complete adjustments in the RER to take place, especially when nominal exchange rates are fixed and overall domestic inflation is low. Further research might estimate a system of equations rather than a single reduced-form equation to capture the adjustment process and the effects of other variables on the RER in Pakistan.

## Equilibrium Real Exchange Rates

The omega parameter estimated using the RER equations above can be used to estimate the equilibrium exchange rate under alternative trade policies.[12] In Table 9 the percentage

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[12] The estimate from regression 5 is used for the calculations because the dummy variables used in the regressions over the entire sample period may not have adequately captured the massive structural changes in the economy resulting from the secession of Bangladesh. Equilibrium exchange rates calculated for the pre-1972 period thus are calculated using an out-of-sample estimate of omega.

## Table 9—Calculation of the equilibrium real exchange rate using the omega approach, 1960-87

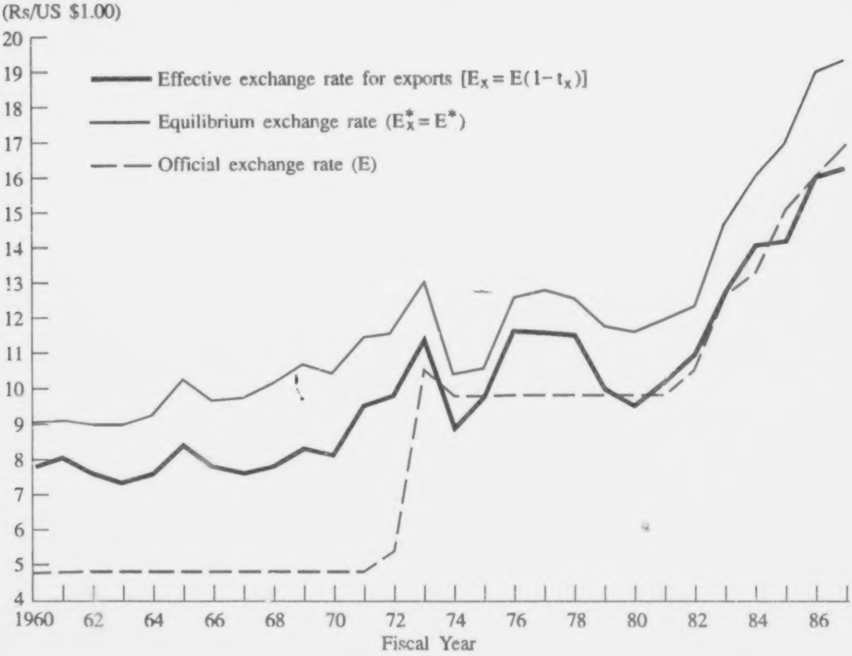
| Year | $RER_x$ (1) | Equivalent Tariff (2) | $(1 + T)^{-\omega}$ (3) | Equilibrium $RER_x$ (4) |
|---|---|---|---|---|
| Year | | | | |
| 1960 | 107.40 | 1.42 | 1.15 | 123.97 |
| 1961 | 106.08 | 1.38 | 1.14 | 121.07 |
| 1962 | 100.02 | 1.45 | 1.17 | 116.62 |
| 1963 | 99.87 | 1.57 | 1.20 | 120.15 |
| 1964 | 99.88 | 1.55 | 1.20 | 119.61 |
| 1965 | 105.84 | 1.61 | 1.22 | 128.74 |
| 1966 | 97.96 | 1.67 | 1.23 | 120.82 |
| 1967 | 88.12 | 1.79 | 1.27 | 111.98 |
| 1968 | 88.03 | 1.81 | 1.28 | 112.32 |
| 1969 | 93.84 | 1.78 | 1.27 | 118.73 |
| 1970 | 91.10 | 1.74 | 1.26 | 114.38 |
| 1971 | 102.31 | 1.62 | 1.22 | 124.55 |
| 1972 | 110.75 | 1.48 | 1.18 | 130.21 |
| 1973 | 129.78 | 1.41 | 1.15 | 149.27 |
| 1974 | 94.56 | 1.47 | 1.17 | 110.83 |
| 1975 | 95.72 | 1.25 | 1.10 | 104.99 |
| 1976 | 103.98 | 1.21 | 1.08 | 112.60 |
| 1977 | 101.36 | 1.30 | 1.11 | 112.70 |
| 1978 | 105.40 | 1.24 | 1.09 | 115.29 |
| 1979 | 99.00 | 1.49 | 1.18 | 116.62 |
| 1980 | 95.86 | 1.62 | 1.22 | 116.76 |
| 1981 | 100.00 | 1.51 | 1.18 | 118.32 |
| 1982 | 93.03 | 1.38 | 1.14 | 106.09 |
| 1983 | 100.73 | 1.41 | 1.15 | 115.92 |
| 1984 | 103.33 | 1.40 | 1.15 | 118.51 |
| 1985 | 93.51 | 1.53 | 1.19 | 111.23 |
| 1986 | 114.24 | 1.51 | 1.18 | 135.37 |
| 1987 | 125.38 | 1.54 | 1.19 | 149.78 |
| Average | | | | |
| 1960-71 | 98.37 | 1.62 | 1.22 | 119.41 |
| 1972-77 | 106.03 | 1.35 | 1.13 | 120.10 |
| 1978-82 | 98.66 | 1.45 | 1.16 | 114.62 |
| 1983-87 | 107.44 | 1.48 | 1.17 | 126.16 |

Notes: (1) is the real exchange rate index for exports (1981 = 100).
(2) is equivalent tariff = $1 + T = (1 + t_m) / (1 - t_x)$, where $t_m$ is the import tariff and $t_x$ is the export tax .
(3) is misalignment in the real exchange rate ($\omega = -0.410$).
(4) is the equilibrium real exchange rate index = $RER_x \cdot (1 + T) - \omega$.

change in the RER for exports is calculated under the assumption that the implicit import tariff and the implicit export tax are reduced to zero $[(1 + t_m)/(1 - t_x) = 1]$. For example, in 1981, removing all trade tariffs and taxes reduces $(1 + t_m)/(1 - t_x)$ from 1.51 percent to 1.00 (a reduction of $0.51/1.51 = 33.8$ percent) and results in a depreciation of the RER by $-33.8 \cdot -0.410 = 13.86$ percent.

Reducing tariffs to zero in the pre-1972 period, when $(1 + t_m)/(1 - t_x)$ averaged 1.62, would have resulted in a 22 percent depreciation of the RER for exports, compared with historical levels (Table 9). As shown in Figure 5, the gap between the official exchange rate (which applied to some agricultural products) and the calculated equilibrium exchange rate is even larger. Under the government of Zulfiqar Ali Bhutto, $(1 + t_m)/(1 - t_x)$ averaged only 1.35, so that removal of all trade barriers would have resulted in a smaller depreciation (13 percent) of the RER. Implicit tariffs have changed little

**Figure 5—Nominal exchange rates, 1960-87**



Source: Derived from basic data in Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

in the 1980s despite a large depreciation of the nominal (and real) exchange rates. Thus the overvaluation of the rupee caused by trade policy has persisted.

The role of reduced levels of workers' remittances in the 1980s on the RER can also be estimated from the RER equation parameters. Private transfers (mostly workers' remittances) rose sharply from the early 1970s to 1984, with the ratio of remittances to GDP increasing nearly fivefold over this period. Had remittances relative to real GDP remained at the 1973 level and implicit tariffs and taxes, terms of trade, and capital inflows remained unchanged, the equilibrium RER in 1984 would have been 20.1 percent higher. Similarly, if the ratio of remittances to real GDP had remained at the 1984 peak level, the equilibrium RER would have been 9 percent lower in 1987, all else remaining the same. Based on the 1987 level of workers' remittances of more than US$2.6 billion, each reduction of US$500 million in remittances would result in a 2.6 percent depreciation of the RER.

## Elasticities Approach

An alternative method of determining the equilibrium RER is a variant of the elasticities approach, which is based on estimated import demand and export supply elasticities. The essence of the approach is to calculate the change in the RER required to eliminate the unsustainable part of the deficit in the current account and the elimination of trade interventions. Following Krueger, Schiff, and Valdés (1988),

$$E^* = E \cdot \frac{Q_0 + [t_m/(1 + t_m)] \cdot n_D Q_D - [t_x/(1 - t_x)] \cdot e_S Q_S}{(e_S Q_S + n_D Q_D)} + 1, \tag{11}$$

where

$E^*$ = the equilibrium real exchange rate,
$E$ = the official nominal exchange rate,
$Q_0$ = unsustainable deficit in the current account = $Q_D - Q_S$,
$n_D$ = the elasticity of demand for foreign exchange (the elasticity of demand for imports),
$Q_D$ = the demand for foreign exchange (the level of imports),
$e_S$ = the elasticity of supply of foreign exchange (the elasticity of supply of exports), and
$Q_S$ = the supply of foreign exchange (the level of exports).

Two series of equilibrium exchange rates calculated using the elasticities approach are presented in Table 10.[13] In the first series ($E_1^*$), equilibrium is calculated with no tariffs and a balance of trade of zero (remittances are included as exports). The second series ($E_2^*$), which is more directly comparable to the series obtained using the RER regression, assumes zero tariffs and the same balance of trade as historically observed. For both series, the export supply elasticity is assumed to be 1.0 and the import demand elasticity is assumed to be −2.0.[14]

The elasticities approach ignores changes in the prices of home goods resulting from an exchange rate devaluation. Thus a given percentage change in the nominal exchange rate implies the same percentage change in the real exchange rate. In order to facilitate comparison with the equilibrium exchange rates calculated using the elasticities approach, the equilibrium real exchange rate calculated using the omega approach is expressed in Table 11 as a nominal exchange rate. Assuming that monetary policy is adjusted to keep the price of nontradables equal to its historical level, the calculated percentage change in the real exchange rate for exports is equal to the percentage change in the nominal exchange rate for exports.

Figure 6 compares the equilibrium exchange rates derived from the RER equation (Table 11) and from the elasticities approach (Table 10, $E_1^*$). A constant RER series

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[13] For the years prior to 1973, when Pakistan had multiple exchange rates, the effective exchange rate for exports is used in place of the official nominal exchange rate as a base for the calculations. The ratio $(1 + t_m)/(1 - t_x)$ is used in place of the implicit import tariff, and the export tax (subsidy) is set to zero. Results of an alternative approach that uses the actual $t_m$ and $t_x$ values for all years of the series are shown in Appendix 1, Table 28.

[14] The calculations shown in Table 10 rely heavily on the estimates of the trade elasticities. Nabi, Hamid, and Nasim (1987) also used the elasticities approach (and the same parameter assumptions) to calculate the real exchange rage adjustment, but their results differ markedly for the early years of the period because of higher estimates of the equivalent tariff (calculated using Sjaastad's [1981] import regression residuals method).

## Table 10—Equilibrium exchange rates using an elasticities approach, 1960-87

| Year | $1 + t_m$ | $1 - t_x$ | $Q_1$<br>(Rs million) | E | $E_1^*$ | $E_2^*$ |
|---|---|---|---|---|---|---|
| 1960 | 2.34 | 1.65 | 2,360 | 4.78 | 8.54 | 7.37 |
| 1961 | 2.34 | 1.69 | 2,699 | 4.79 | 9.08 | 7.44 |
| 1962 | 2.36 | 1.62 | 2,775 | 4.77 | 9.07 | 7.42 |
| 1963 | 2.45 | 1.56 | 3,655 | 4.79 | 8.81 | 7.46 |
| 1964 | 2.52 | 1.62 | 3,995 | 4.79 | 8.85 | 7.52 |
| 1965 | 2.85 | 1.77 | 5,239 | 4.80 | 9.26 | 7.79 |
| 1966 | 2.73 | 1.64 | 4,100 | 4.79 | 8.83 | 7.64 |
| 1967 | 2.86 | 1.59 | 5,180 | 4.80 | 9.07 | 7.73 |
| 1968 | 3.01 | 1.66 | 5,088 | 4.79 | 8.73 | 7.74 |
| 1969 | 3.14 | 1.77 | 4,880 | 4.80 | 8.68 | 7.82 |
| 1970 | 3.02 | 1.73 | 5,075 | 4.79 | 8.74 | 7.76 |
| 1971 | 3.22 | 2.00 | 5,925 | 4.78 | 8.77 | 7.89 |
| 1972 | 2.65 | 1.78 | 5,873 | 5.56 | 8.70 | 8.69 |
| 1973 | 1.53 | 1.08 | 6,486 | 10.56 | 12.96 | 13.21 |
| 1974 | 1.33 | 0.90 | 5,491 | 9.90 | 12.05 | 11.34 |
| 1975 | 1.24 | 0.99 | 7,985 | 9.90 | 13.15 | 11.38 |
| 1976 | 1.44 | 1.19 | 14,781 | 9.90 | 13.67 | 12.55 |
| 1977 | 1.53 | 1.18 | 18,502 | 9.90 | 13.80 | 12.82 |
| 1978 | 1.46 | 1.17 | 21,177 | 9.90 | 12.83 | 12.50 |
| 1979 | 1.51 | 1.01 | 24,891 | 9.90 | 12.73 | 12.26 |
| 1980 | 1.55 | 0.96 | 31,567 | 9.90 | 12.59 | 12.21 |
| 1981 | 1.55 | 1.03 | 39,513 | 9.90 | 12.46 | 12.36 |
| 1982 | 1.44 | 1.04 | 38,335 | 10.55 | 13.41 | 12.92 |
| 1983 | 1.42 | 1.01 | 41,046 | 12.70 | 14.84 | 15.18 |
| 1984 | 1.47 | 1.05 | 52,714 | 13.48 | 16.55 | 16.56 |
| 1985 | 1.46 | 0.95 | 52,557 | 15.16 | 19.07 | 18.27 |
| 1986 | 1.52 | 1.00 | 62,226 | 16.13 | 19.81 | 19.81 |
| 1987 | 1.47 | 0.95 | 52,432 | 17.17 | 19.90 | 20.40 |

Notes: $t_m$ is the implicit import tariff and $t_x$ is the implicit export tax.

$Q_1$ = current account imbalance due to trade taxes and quotas.

= $[t_m/(1 + t_m] \cdot Q_D \cdot n_D [t_x/(1 - t_x) \cdot (Q_s + \text{Remit})] \cdot e_S$ ,

E = the actual nominal exchange rate,

$$E_1^* = E \cdot \left\{ \frac{(\text{Current account deficit} + Q_1)}{[Q_D \cdot n_D + (Q_S + \text{Remit}) \cdot e_S]} + 1, \right\}$$

$E_2^*$ = $E \cdot \{Q_1 \cdot / [Q_D \cdot n_D + (Q_S + \text{Remit}) \cdot e_S] + 1\}$ ,

Remit = workers' remittances,

$Q_D$ = the demand for foreign exchange (the level of imports),

$n_D$ = the elasticity of supply of foreign exchange (the elasticity of demand for imports),

$Q_S$ = the supply of foreign exchange (the level of exports), and

$e_S$ = the elasticity of supply of foreign exchange (the elasticity of supply of exports).

(purchasing power parity with the 1974 nominal exchange rate as a base) is also included (Table 11). The equilibrium exchange rates calculated using the ω parameter and those calculated using the elasticities approach follow approximately the same path except for the late 1960s and early 1970s. A rise in the export subsidy accounts for much of the divergence between the series in the late 1960s (because changes in the export subsidy directly affect the effective exchange rate for exports on which the ω exchange rate series is based, but indirectly affect the exchange rate series using the elasticities approach through changes in calculated export supply).

## Table 11—Equilibrium nominal exchange rates and purchasing power parity, 1960–87

| Year | E (1) | $E_x$ (2) | EPPP (3) | $E_x^*$ (4) | $E_x$/EPPP (5) | $E_x^*$/EPPP (6) |
|---|---|---|---|---|---|---|
| | | (Rs/US$) | | | (percent) | |
| 1960 | 4.78 | 7.89 | 8.12 | 9.10 | –2.93 | 12.05 |
| 1961 | 4.79 | 8.10 | 8.44 | 9.24 | –4.02 | 9.55 |
| 1962 | 4.77 | 7.74 | 8.56 | 9.02 | –9.63 | 5.37 |
| 1963 | 4.79 | 7.48 | 8.28 | 9.00 | –9.65 | 8.70 |
| 1964 | 4.79 | 7.77 | 8.60 | 9.31 | –9.63 | 8.22 |
| 1965 | 4.80 | 8.49 | 8.86 | 10.33 | –4.13 | 16.62 |
| 1966 | 4.79 | 7.84 | 8.84 | 9.66 | –11.34 | 9.34 |
| 1967 | 4.80 | 7.65 | 9.60 | 9.73 | –20.24 | 1.36 |
| 1968 | 4.79 | 7.95 | 9.68 | 10.14 | –17.88 | 4.78 |
| 1969 | 4.80 | 8.50 | 9.52 | 10.76 | –10.66 | 13.03 |
| 1970 | 4.79 | 8.30 | 9.58 | 10.42 | –13.37 | 8.77 |
| 1971 | 4.78 | 9.54 | 9.82 | 11.62 | –2.79 | 18.34 |
| 1972 | 5.56 | 9.92 | 9.64 | 11.67 | 2.97 | 21.06 |
| 1973 | 10.[illegible]5 | 11.45 | 9.34 | 13.17 | 22.69 | 41.11 |
| 1974 | 9.90 | 8.93 | 9.90 | 10.46 | –9.81 | 5.71 |
| 1975 | 9.90 | 9.77 | 10.68 | 10.71 | –8.53 | 0.34 |
| 1976 | 9.90 | 11.75 | 11.21 | 12.73 | 4.89 | 13.59 |
| 1977 | 9.90 | 11.68 | 10.89 | 12.99 | 7.32 | 19.33 |
| 1978 | 9.90 | 11.58 | 10.61 | 12.67 | 9.19 | 19.44 |
| 1979 | 9.90 | 10.00 | 10.03 | 11.78 | –0.30 | 17.46 |
| 1980 | 9.90 | 9.49 | 10.17 | 11.56 | –6.70 | 13.64 |
| 1981 | 9.90 | 10.17 | 10.56 | 12.03 | –3.66 | 13.99 |
| 1982 | 10.55 | 11.01 | 11.43 | 12.56 | –3.63 | 9.91 |
| 1983 | 12.70 | 12.81 | 11.79 | 14.74 | 8.68 | 25.06 |
| 1984 | 13.48 | 14.21 | 12.32 | 16.30 | 15.33 | 32.28 |
| 1985 | 15.16 | 14.46 | 13.09 | 17.19 | 10.42 | 31.34 |
| 1986 | 16.13 | 16.18 | 12.71 | 19.17 | 27.30 | 50.84 |
| 1987 | 17.17 | 16.35 | 11.88 | 19.53 | 37.64 | 64.42 |

Notes: (1) E = nominal exchange rate,

(2) $E_x$ = nominal exchange rate (E) • $(1 - t_x)$, where $t_x$ is the export tax,

(3) EPPP(t) = Purchasing power parity exchange rate = E (1974) • CPI(t) / WWPI(t), where CPI is an index of consumer prices in Pakistan andWWPI is an index of wholesale prices of Pakistan's trading partners measured in U.S. dollars.

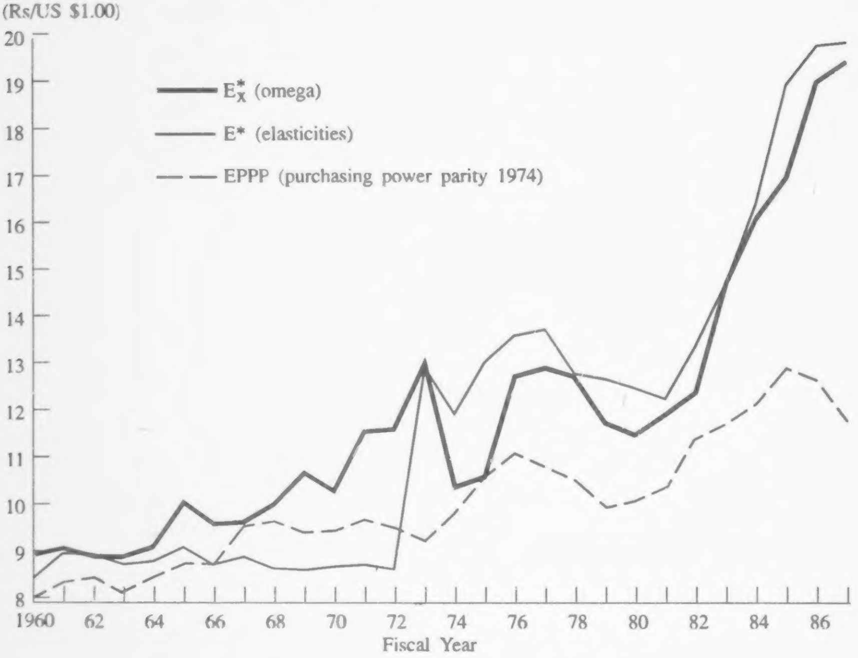
(4) $E_x^*$ = equilibrium effective exchange rate for exports = equilibrium nominal exchange rate ($t_x$ and $t_m = 0$), where $t_x$ is the export tax and $t_m$ is the implicit import tariff.

(5) $E_x$/EPPP = percentage deviation of $E_x$ from EPPP, and

(6) $E_x^*$/EPPP = percentage deviation of $E_x^*$ from EPPP.

Both the elasticity and omega free-trade equilibrium exchange rate series fluctuate greatly from 1972 to 1974, a period during which the Pakistan economy was subject to a number of major shocks: war with India, the secession of East Pakistan (Bangladesh), a major devaluation and restructuring of the exchange rate system and later a revaluation of the exchange rate. One reason for the instability in the calculated free-trade equilibrium exchange rates may be the underlying disequilibrium in the actual exchange rates on which the calculated series are based. (Both approaches to calculating the free-trade equilibrium exchange rate are essentially comparative static approaches, which implicitly assume that the observed historical exchange rates, trade levels, and other macroeconomic variables are in equilibrium).

**Figure 6—Equilibrium exchange rates, 1960-87**



Source: Derived from basic data in Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

All three series are similar from 1974 to 1982. The sharp increase in the omega and elasticity approach series relative to the constant purchasing power parity series after 1982 reflects the underlying depreciation of the nominal exchange rate in the 1980s in response to changes in Pakistan's external environment (decreasing worker remittances), policy decisions (unwillingness to greatly increase foreign borrowing to compensate for lower foreign exchange earnings), and other factors.

In sum, Pakistan's trade policies have consistently favored import-competing sectors at the expense of the export sector over the last three decades. Tariffs and quotas on imports have not only raised the domestic price of importables relative to exportables, but by increasing the demand for home goods, have led to an increase in the price of home goods relative to export goods (an appreciation of the RER for exports). Calculations based on regression results show that a removal of trade taxes and quantitative restrictions would have resulted in an average RER depreciation of 17 percent relative to historical values from 1982 to 1987.

## 6

# EFFECTS OF TRADE AND EXCHANGE RATE POLICIES ON AGRICULTURAL PRICES

In Pakistan, a number of policy instruments, including export taxes, government monopolies on trade, producer support prices, and input subsidies, have been used in an attempt to influence agricultural output prices and the costs of production. The import substitution bias in industrial trade policy and the resulting appreciation of the real exchange rate (RER) discussed in the previous section have also indirectly affected the prices of agricultural commodities relative to nonagricultural goods.

In this section, the effects of government policies on agricultural price incentives are analyzed. Following the framework set forth in Krueger, Schiff, and Valdés (1988), the effects of agricultural trade and price policies (direct effects) are quantified in terms of nominal and effective rates of protection for major agricultural commodities, calculated using historical nominal exchange rates in determining border prices.[15] The indirect effects of overall trade policy and appreciation of the RER are then included in measures of the total effects on prices and value added by using the free-trade equilibrium RERs of the previous section.

## Direct Effects on Output Prices: Nominal Rates of Protection

Agricultural trade and price policies (including trade taxes, quotas, government monopolies on trade, and marketing and processing subsidies) have a direct effect on output prices. Nominal rates of protection measure these direct effects on output prices by comparing actual domestic prices with free-trade prices that would prevail in the absence of government intervention.

$$NRP_i = (P_i - P_i')/P_i' = P_i/P_i' - 1, \tag{12}$$

where $NRP_i$ is the nominal rate of protection on good i, $P_i$ is the domestic price of good i, and $P_i'$ is the border or world price of good i adjusted for transport and other marketing costs.

In this section, nominal rates of protection are calculated for agricultural commodities based on prices received by farmers. $P_i$ is measured as the support price of the commodity or the wholesale price less marketing costs from farmgate to wholesale market.

Defining the border price is somewhat more difficult because of differences in quality and degree of processing between commodities traded on the world market and the farmers' product. In general, for an exportable good, the border price measured at the farmgate is defined as the world price less the cost of export handling, transport, and marketing not only to the port but also between the farmgate and the local wholesale market (in order to make a comparison with farmgate prices). The world price is measured as the price in a major export market adjusted for transport and quality differences or as the actual average export price received for Pakistan's exports. For importable goods the border price is defined as the world price (equal to the c.i.f. import price) plus costs of unloading, transport to the wholesale market, and marketing less transport and marketing costs between the farmgate and the wholesale market.

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[15] The Krueger, Schiff, and Valdés (1988) framework was also used by Nabi, Hamid, and Nasim (1987) in their estimations of effects of policies on agricultural prices.

## Indirect and Total Effects

Nominal rates of protection, calculated using the official exchange rate, measure only the direct effects of trade policy. However, exchange rates as well as trade policies affect border prices and the opportunity costs of production and consumption. In order to capture the indirect effects of misalignment of the exchange rate, the indirect effects of trade on nonagriculture and of exchange rate policies on farm prices can be measured as

$$\frac{(P_i'/P_{na}) - (P_i^*/P_{na}^*)}{(P_i^*/P_{na}^*)} = \frac{(P_i'/P_{na})}{(P_i^*/P_{na}^*)} - 1$$

$$= \frac{(P_i'/P_{na})}{(E^*/E_0)(P_i'/P_{na}^*)} - 1 = \frac{(E_0/P_{na})}{(E^*/P_{na}^*)} - 1, \qquad (13)$$

where $P_i'$ is the border price of a commodity evaluated at the official exchange rate and $P_i^*$ at the equilibrium exchange rate; $E^*/E_0$ measures the exchange rate adjustment; $P_{na}$ is the price index of nonagriculture; and $P_{na}^*$ is the price index of nonagriculture with free trade and an equilibrium exchange rate.[16] These indirect effects are of course common to all tradable farm products.[17]

The above measures of indirect effects assume that the prices of nonagricultural goods and services remain unchanged. However, as argued by Valdés (1986), long-term investments in agriculture are a function of the relative prices of agricultural to nonagricultural goods (the domestic terms of trade of agriculture).[18] Thus the ratio of the output price of a commodity to the price of nonagricultural goods is the appropriate measure of the incentives. And because trade and exchange rate policies affect the prices of nonagricultural goods as well as agricultural goods, the total effect (direct plus indirect) of policy on agricultural relative prices is[19]

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[16] In this study, the equilibrium exchange rate, $E_x^*$, calculated using the omega approach (Table 11), is used as the estimate of the equilibrium exchange rate, $E^*$. The estimates $E_1^*$ or $E_2^*$, calculated using the elasticities approach (Table 10), are presented for comparison purposes only.

[17] Whereas the indirect effect is common to all tradables, the estimates of the direct, indirect, and total price effects are done successively, so the numerical value of the indirect effect reported varies by commodity. Alternatively, the direct and indirect effects can be expressed as a percentage of the total effect, in which case the indirect effect is common to all tradables.

[18] See also Mundlak, Cavallo, and Domenech 1989a and 1989b.

[19] Note that the formula for the nominal rate of protection can also be written in this form but, since the calculation of direct effects assumes no changes in overall trade policy or exchange rates, $P_{na}' = P_{na}$, and $NRP_i = (P_i/P_{na} - P_i'/P_{na}')/(P_i'/P_{na}') = (P_i - P_i')/P_i'$. Estimated values of $P_{na}$, $P_{na}'$, and $P_{na}^*$ are reported in Appendix 3, Table 32, and the methodology is described in Appendix 4.

$$[(P_i/P_{na}) - (P_i^*/P_{na}^*)]/(P_i^*/P_{na}^*) = (P_i/P_{na})/(P_i^*/P_{na}^*) - 1. \tag{14}$$

This equation measures the combined effects of sectoral and economy-wide price interventions on agricultural prices and is the measure of price incentives used in this study; the total effect on output prices can thus be interpreted as nominal rates of protection adjusted by sectoral and economy-wide policies.

## Output Price Effects: Pakistan 1961-87

In estimating the nominal rates of the direct and total effects of government trade and exchange rate policies on output (producer) prices (Table 12), import parity prices are used as world prices for wheat, sugarcane, vegetable oil, maize, and fertilizer; for rice and cotton, export parity prices are used.[20] The producer prices are annual prices at harvest time. In the case of wheat, the producer price is used and is very close to the market price. Details of the calculations are given in Appendix 2.

### Wheat

The direct effect of trade and agricultural price policies on wheat in the early 1960s was small, but from 1966 to 1971, domestic wheat prices were on average 28 percent higher than import parity prices when evaluated at the official exchange rate (see Table 12 and Figure 7).[21] Including the indirect effects of the appreciation of the RER, however, the total effect of government policy on farmgate prices of wheat averaged −46 percent in this period.

After the devaluation of 1972 and throughout most of the 1970s and 1980s, the farmgate support prices were kept below the import parity price measured using the official exchange rate. During Bhutto's administration (1972-77), world wheat prices were high, especially during 1972-74, but average domestic producer prices changed little in real terms compared with the 1966-71 period; as a result the nominal rate of protection fell to −38 percent. The border price of wheat measured in real terms ($P_w^*/P_{na}^*$) fell by 40 percent between the 1961-65 and 1983-87 periods (the 1972-74 rise in world prices was an exception to the overall trend), while farmer support prices declined by only 22 percent so that the total (direct plus indirect) effects of government policies decreased in absolute magnitude from −49 to −33 percent.

In recent years Pakistan has imported only small quantities of wheat for domestic purposes. (Significant quantities have been imported for use at Afghan refugee camps, however.) As shown in Figure 7, domestic procurement prices have been below or near export parity border prices evaluated at the official exchange rate in most years since 1977. In the 1983-87 period, farmgate prices were on average 15 percent above export parity prices using the official exchange rate, but 7 percent below export parity prices using an equilibrium exchange rate.

### Basmati Rice

Trade policies have had large direct effects on basmati rice prices. Export taxes and profits to government trading corporations reduced farmgate prices to half or less

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[20] Although Pakistan receives some food aid, these food aid flows are inframarginal, and thus the opportunity cost at the margin is still the border price.

[21] Nabi, Hamid, and Nasim (1987) include a detailed summary of the policy measures underlying the measured price effects for wheat, basmati rice, ordinary rice, cotton, and sugarcane.

## Table 12—Direct and total nominal protection rates to producers of agricultural commodities, 1961-87

| Commodity/ NPR | Annual Average | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1961-65 | 1966-71 | 1972-77 | 1978-82 | Average 1983-87 | Average 1961-71 | 1972-87 |
| | | | | (percent) | | | |
| Importables | | | | | | | |
| Wheat | | | | | | | |
| Direct effect | 8 | 28 | -38 | -34 | -19 | 19 | -31 |
| Total effect | -49 | -46 | -56 | -48 | -33 | -48 | -46 |
| Maize | | | | | | | |
| Direct effect | 23 | 37 | -30 | 0 | -1 | 30 | -12 |
| Total effect | -41 | -41 | -52 | -20 | -18 | -41 | -31 |
| Vegetable oil | | | | | | | |
| Direct effect | 4 | 42 | -18 | -36 | -26 | 24 | -26 |
| Total effect | -40 | -21 | -37 | -46 | -35 | -30 | -40 |
| Milk | | | | | | | |
| Direct effect | ... | ... | 51 | 78 | 82 | ... | 61 |
| Total effect | ... | ... | 18 | 51 | 53 | ... | 35 |
| Sugarcane | | | | | | | |
| Direct effect | 538 | -287 | -22 | 30 | 628 | 88 | 197 |
| Total effect | 20 | 63 | -50 | -7 | 210 | 43 | 45 |
| Sugar (ex-mill) | | | | | | | |
| Direct effect | 97 | 154 | -21 | 9 | 69 | 128 | 17 |
| Total effect | 3 | 26 | -43 | -11 | 43 | 16 | -6 |
| Total importables | | | | | | | |
| Direct effect | ... | ... | ... | ... | ... | 21 | 48 |
| Total effect | ... | ... | ... | ... | ... | -11 | 7 |
| Exportables | | | | | | | |
| Basmati | | | | | | | |
| Direct effect | -37 | -14 | -50 | -48 | -57 | -20 | -52 |
| Total effect | -76 | -72 | -67 | -60 | -65 | -73 | -65 |
| Ordinary rice | | | | | | | |
| Direct effect | 16 | 18 | -34 | -38 | 7 | 17 | -23 |
| Total effect | -53 | -60 | -61 | -53 | -17 | -57 | -44 |
| Cotton | | | | | | | |
| Direct effect | 34 | 76 | -10 | 5 | 25 | 57 | 6 |
| Total effect | -46 | -41 | -38 | -20 | -3 | -43 | -21 |
| Total exportables | | | | | | | |
| Direct effect | ... | ... | ... | ... | ... | 28 | -15 |
| Total effect | ... | ... | ... | ... | ... | -54 | -38 |

Source: Author's calculations based on data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The total importable figures are a weighted average of nominal rates of protection of importables. The weights are the relative value shares of production of the selected products (wheat, 33 percent; maize, 2 percent; sugar, 15 percent; vegetable oil, 2 percent; and milk, 48 percent). Total exportables are a weighted average of nominal rates of protection of exportables. The weights are the relative value shares of production (basmati, 19 percent; other rice, 36 percent; and cotton, 45 percent).

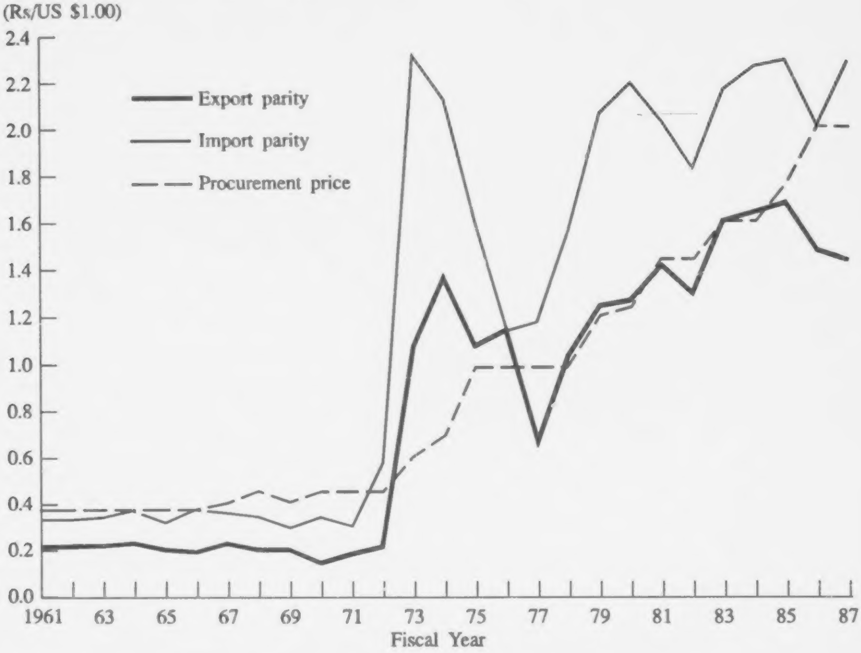
The indirect effect is common to all tradable farm products: however, numerically the implicit indirect effect varies among commodities (see Chapter 6).

Sugar (ex-mill) is not included in the average since the protection is included in sugarcane figures.

of the border price each year from 1979 to 1987, whereas the farmgate prices for paddy were on average 41 percent lower than border prices during the period 1964 to 1987 (see Table 12 and Figure 8). The indirect effect of the appreciation of the RER augmented the direct effect of trade policy so that farmgate prices were on average only one-third the equilibrium exchange rate border prices from 1964 to 1987.

The total effect of government policy on farmgate prices of basmati rice has been remarkably stable, ranging between -60 and -76 percent except in 1977 and 1978

Figure 7—Wheat prices, 1961-87



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-Operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: These are annual prices at harvest time, when the procurement price of wheat is similar to the market price; see Appendix 2 for details.

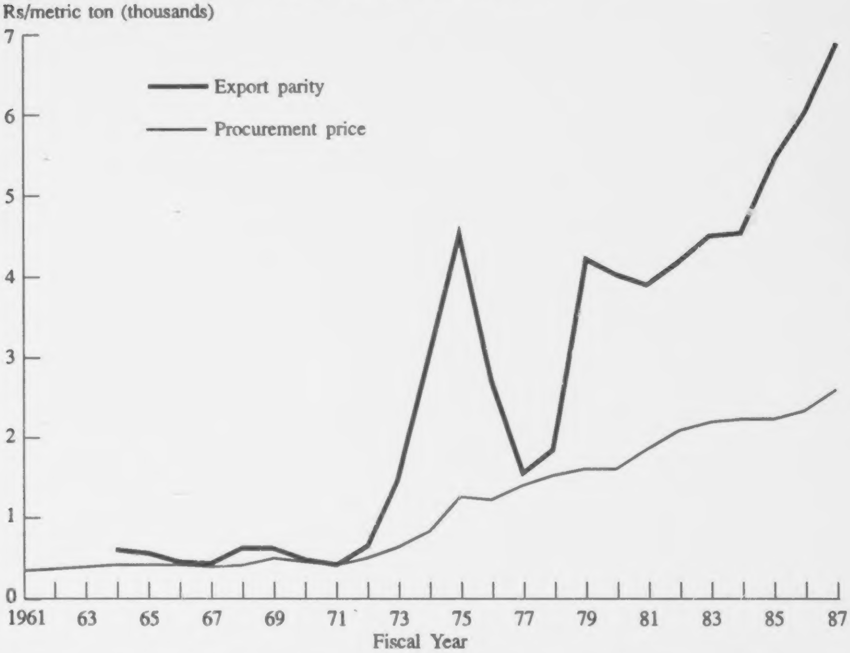
when low world prices did not lead to a corresponding drop in producer support prices.

Although the tax rates on basmati rice have been very high, lower tax rates could result in substantial losses of revenue and foreign exchange if the quantity of exports were increased. Because Pakistan enjoys a virtual monopoly in basmati rice exports on the world market, an increase in farmer prices leading to greater production and increased export supplies would result in lower world rice prices. The same method of estimating rates of production could be extended to adjust to the change in world price resulting from larger basmati exports from Pakistan. This is done in the price model in Chapter 7. In any case, government policies have resulted in a substantial resource transfer from basmati rice farmers to the government.

### Ordinary Rice

The direct and total effects of government policies on ordinary rice (including varieties developed by the International Rice Research Institute and other nonbasmati rice) are smaller than those on basmati rice. They have declined substantially since 1981 as world rice prices have fallen. Government purchase prices for paddy were on

Figure 8—Basmati rice (paddy) prices, 1961-87



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The border price of rice is converted to that of paddy by adjusting for processing and milling costs. If these processing activities are noncompetitive, the measured nominal rates of protection to producers would be understated. However, the difference in nominal rates of protection as a percentage of mean value would be very small.

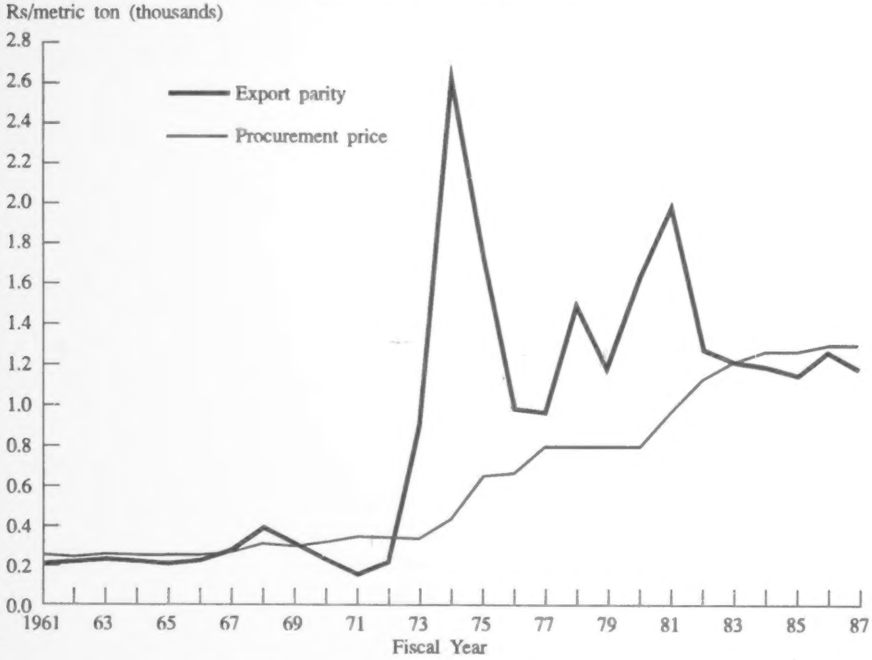
average 17 percent higher than official exchange rate border prices from 1961 to 1971 (see Table 12 and Figure 9). After the devaluation in 1972, the direct effect of trade policies was negative until 1983. The total effect of trade and exchange rate policies, however, was approximately the same throughout the 1960s and 1970s, so that farmers received less than half the free-trade equilibrium border price in most years.

Domestic rice prices did not decline along with world rice prices beginning in 1983. As a result, from 1983 to 1987 border prices (using the official exchange rate) were approximately equal to farmgate prices, and the total effect of government policies on ordinary rice prices was only −17 percent.

## Cotton

Border prices of seed cotton at the farmgate level were constructed using world (f.o.b.) prices of lint cotton and world (c.i.f.) prices of vegetable oil (soybean and palm oil) to derive a border price for cottonseed. Although cottonseed constitutes approximately two-thirds of the weight of cotton, 75-80 percent of the value of the cotton (in

Figure 9—Ordinary rice (paddy) prices, 1961-87



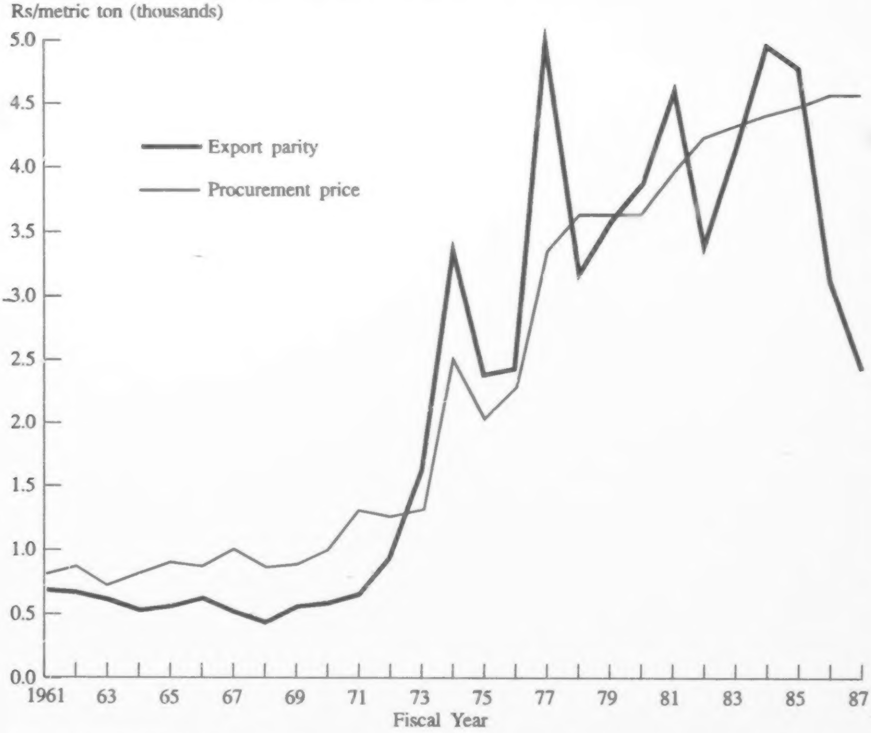
Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (islamabad: Ministry of Finance, various years).

Notes: The border price of rice is converted to that of paddy by adjusting for processing and milling costs. Because these costs are protected, the tax is overstated, but the adjustment is very small compared with overall nominal rates of protection.

1987 world prices) derives from the cotton fibers (cotton lint). The implicit tax on cotton lint is thus the major factor in determining the rate of protection on cotton.

During the 1960s, domestic prices of cotton were higher than border prices evaluated at the official exchange rate (Figure 10). Protection provided by direct trade policies was outweighed by the implicit taxation resulting from exchange rate policies, so that the total effect of government policy was a farmgate price 30-52 percent lower than the border price. After the devaluation of 1972, direct taxes levied on raw cotton exports kept domestic raw cotton prices an average of 10 percent below border prices. From 1978 to 1985, the direct effect of trade policies on cotton prices was small in most years. Finally, the sharp reduction in world cotton prices in 1986 and 1987 eliminated the longstanding disprotection of lint cotton. Domestic support prices for cotton declined only slightly in real terms in 1986 and 1987 so that by 1987 real farmgate prices of cotton were 49 percent higher than real, free-trade equilibrium border prices. Thus, there was an implicit subsidy on exports of lint cotton in these years.

**Figure 10—Seed cotton prices, 1961-87**



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

### Vegetable Oil

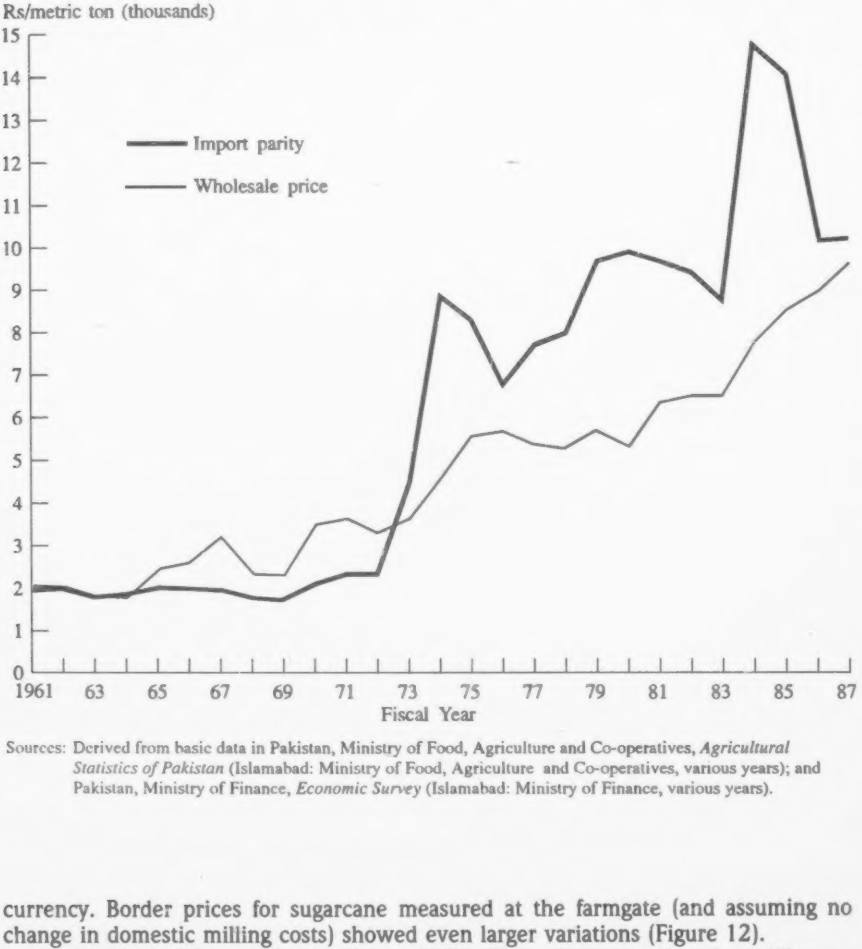
In the calculations of direct and total effects for vegetable oil prices, the domestic wholesale price of cottonseed oil is compared with the average of the border prices of soybean and palm oils (edible oils imported by Pakistan). No quality adjustment is made in comparing the prices of the oils.

From 1965 until the devaluation of 1972, the domestic price of cottonseed oil was consistently above the border price of imported edible oils (converted to rupees at the official exchange rate). Since 1973, it has been below (see Figure 11). When indirect effects of exchange rate policies are considered, domestic prices were below border prices every year, averaging 36 percent below border prices of imported vegetable oils.

### Sugarcane

World prices of refined sugar are extremely variable, which causes measures of protection provided by government policies to fluctuate wildly. The real border price $(P^*_s/P^*_{na})$ of refined sugar (ex-mill) varied from Rs 1,649 to Rs 14,077 per ton in 1981

**Figure 11—Vegetable oil prices, 1961-87**



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

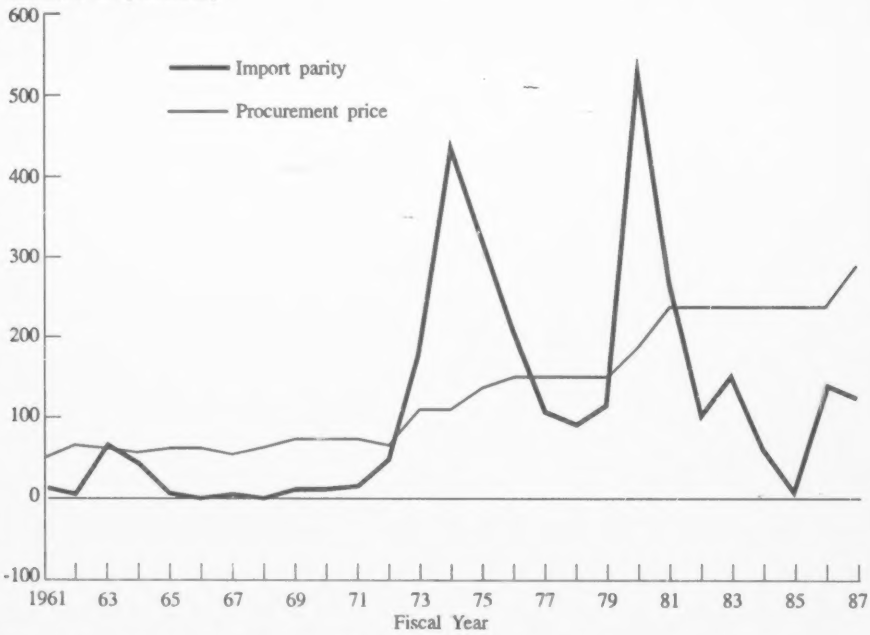
currency. Border prices for sugarcane measured at the farmgate (and assuming no change in domestic milling costs) showed even larger variations (Figure 12).

In 15 of the 27 years from 1961 to 1987, domestic sugar prices (ex-mill) were higher than border prices evaluated at the free-trade-equilibrium exchange rate, while in 12 of the years they were lower. Since 1982, domestic sugar prices (ex-mill) and farmgate sugarcane prices have both been above their corresponding free-trade equilibrium border prices, by an average of 43 and 210 percent, respectively.

### Maize

Maize prices (at the official exchange rate) have fluctuated around import parity prices since the mid-1970s (Figure 13). Between 1978 and 1987, however, farmgate prices were on average 19 percent below border prices evaluated at the equilibrium exchange rate. For the overall period 1961-87, farmgate prices averaged 35 percent below import parity (using equilibrium exchange rates).

Figure 12—Sugarcane prices, 1961-87



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

### Milk

The direct effect of trade and agricultural price policies on milk was large and positive during the 1972-87 period (data on import unit values prior to 1972 are not available). From 1978 to 1987, the domestic prices of milk were, on average, 80 percent higher than the import parity prices. Using the equilibrium exchange rates for 1972-87, there was an average subsidy on milk of 35 percent.[22]

### Fertilizer

In calculating direct and total effects on fertilizer prices, domestic fertilizer prices are compared with import border prices constructed using a weighted average of urea and diammonium phosphate prices. From 1961 to 1972, domestic prices were above world prices at the official exchange rate (Figure 14). After the devaluation, the direct effect of trade policy on fertilizer output prices was negative. World prices at the

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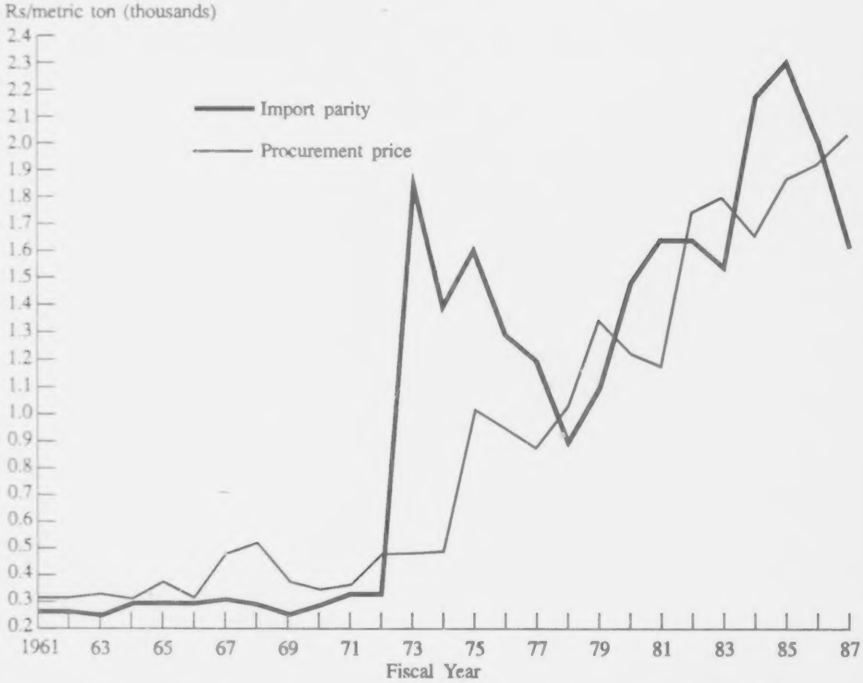
[22] The historical value of production of milk is high (Rs 40,253 million in 1986-87) compared with that of cereals (Rs 28,502 million for wheat and Rs 2,692 million for basmati rice in the same period). That the average protection on importables is positive in spite of the high taxation on cereals reflects that fact.

Figure 13—Maize prices, 1961-87



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

equilibrium exchange rate, used as a measure, indicate that there was an average subsidy of 40 percent on domestic fertilizer from 1961 to 1987.

## Effective Rates of Protection

Government trade and exchange rate policies influence the prices of tradable inputs into agricultural production as well as output prices. The direct effects on value added per unit of output of commodity i (value of output less value of nonfactor inputs) are measured by the effective rate of protection, defined as

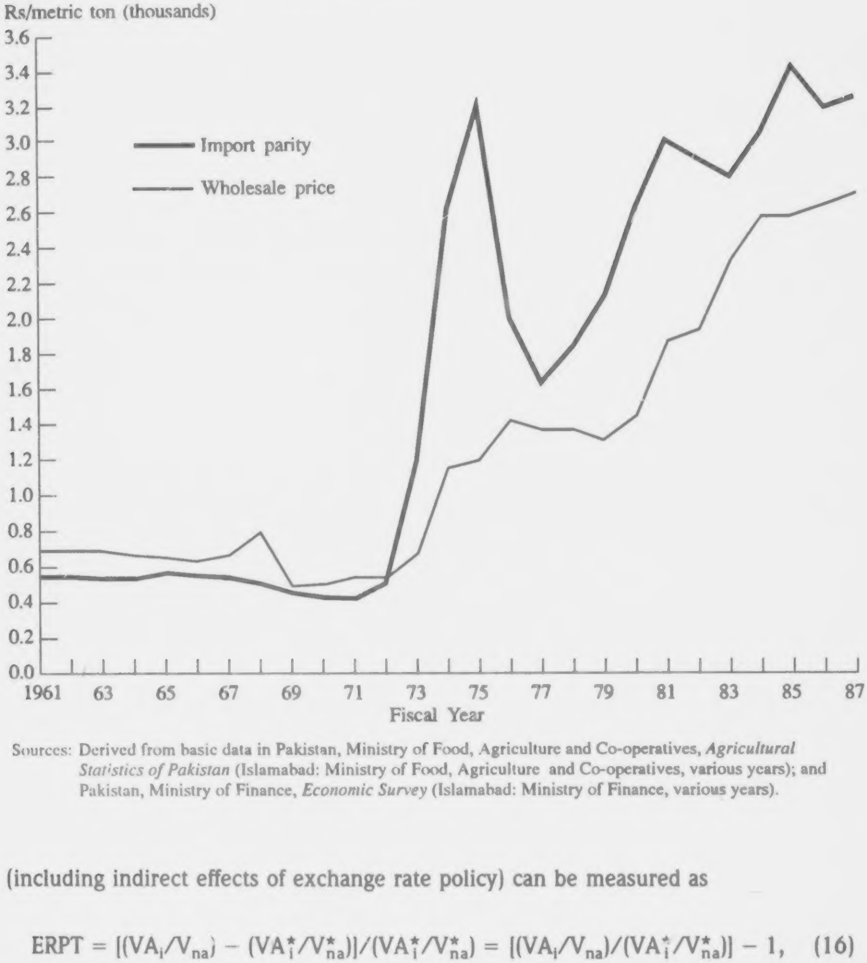
$$ERP_i = (VA_i - VA_i')/VA_i' = VA_i/VA_i' - 1, \tag{15}$$

where ERP is the effective rate of protection and VA is the value added.[23] Total effects

---

[23] Or equivalently, $ERP_i = [(VA_i/V_{na}) - (VA_i'/V_{na})]/(VA_i'/V_{na}) = (VA_i - VA_i')/VA_i'$.

**Figure 14—Fertilizer prices, 1961-87**



Sources: Derived from basic data in Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years); and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

(including indirect effects of exchange rate policy) can be measured as

$$ERPT = [(VA_i/V_{na}) - (VA_i^*/V_{na}^*)]/(VA_i^*/V_{na}^*) = [(VA_i/V_{na})/(VA_i^*/V_{na}^*)] - 1, \quad (16)$$

where $V_{na}$ represents value added in the nonagricultural sector and the asterisks indicate that the value added is measured using border prices valued at the equilibrium exchange rate.

However, adjusting $V_{na}$ to $V_{na}^*$ is beyond the scope of this study, and $P_{na}$ and $P_{na}^*$ are used as proxies. Input costs used to calculate value added by crop are based on cost-of-production data for a single year. The time series of input costs assume constant yields and constant input-output relations. Prices of inputs are estimated using price indices of fertilizer, nonagricultural goods and services, and nontraded goods.

In calculating the direct effects of policy on value added, border prices of fertilizer are used, assuming free trade in agricultural inputs, but no change in exchange rates.

For the calculations of total effects of policy on value added, input cost estimations include effects of exchange rate changes. The price index of nonagricultural goods and services under free trade with equilibrium exchange rates ($P^*_{na}$) is used in estimating changes in prices of some inputs including irrigation (tubewells and canals), tractor services and plant protection. For sugarcane, cotton, and rice, domestic processing costs are assumed to be unchanged in the calculations of effective rates of protection. To the extent that processing costs are inefficient, costs of production at world prices are overestimated and effective rates of protection underestimated. Details of the calculations are given in Appendix 3.

Table 13 presents results of calculations of the value added and effective rates of protection for wheat, basmati rice, ordinary rice, cotton, and sugarcane. Because value added at world prices is small in some years, the effective rates of protection estimated can be extremely large. In general, the pattern of effective rates of protection is similar to that of direct and total effects of output prices, since traded input costs are small for most commodities considered.

## Table 13—Measures of direct and total effective rates of protection to agricultural producers, 1961–87

| Commodity/ NPR | Annual Average 1961-65 | 1966-71 | 1972-77 | 1978-82 | 1983-87 | Average 1961-71 | Average 1972-87 |
|---|---|---|---|---|---|---|---|
| | | | | (percent) | | | |
| Importables | | | | | | | |
| Wheat | | | | | | | |
| Direct effect | 1 | 36 | −44 | −42 | −25 | 20 | −37 |
| Total effect | −60 | −55 | −62 | −56 | −42 | −57 | −54 |
| Sugarcane | | | | | | | |
| Direct effect | 1,751 | 510 | −18 | 97 | −435 | 1,074 | −112 |
| Total effect | 108 | 393 | −52 | 18 | 121 | 263 | 24 |
| Maize | | | | | | | |
| Direct effect | 87 | 141 | 17 | 92 | −10 | 117 | 32 |
| Total effect | −28 | −19 | −26 | 41 | −30 | −23 | −6 |
| Total importables | | | | | | | |
| Direct effect | . . . | . . . | . . . | . . . | . . . | 351 | −57 |
| Total effect | . . . | . . . | . . . | . . . | . . . | 44 | −28 |
| Exportables | | | | | | | |
| Basmati | | | | | | | |
| Direct effect | −61 | −39 | −64 | −61 | −72 | −44 | −65 |
| Total effect | −88 | −86 | −78 | −72 | −78 | −86 | −76 |
| Ordinary rice | | | | | | | |
| Direct effect | 16 | 29 | −38 | −49 | 12 | 26 | −26 |
| Total effect | −65 | −69 | −69 | −63 | −22 | −68 | −53 |
| Cotton | | | | | | | |
| Direct effect | 34 | 142 | −11 | 16 | 117 | 93 | 38 |
| Total effect | −61 | −55 | −44 | −18 | 27 | −58 | −14 |
| Total exportables | | | | | | | |
| Direct effect | . . . | . . . | . . . | . . . | . . . | 43 | −3 |
| Total effect | . . . | . . . | . . . | . . . | . . . | −67 | −43 |

Source: Author's calculations based on data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: Total importables is a weighted average of effective rates of protection of importables. The weights are the relative value shares of production (wheat, 65 percent; sugarcane, 31 percent; and maize, 4 percent). Total exportables is a weighted average of effective rates of protection of exportables. The weights are the relative shares of production (basmati, 19 percent; other rice, 36 percent; and cotton, 45 percent).

Apart from the objective of influencing the average level of prices, one of the reasons why the Pakistan government intervenes in agricultural markets is to provide greater year-to-year price stability for both producers and consumers. Table 14 presents the coefficients of variation for real agricultural prices (nominal prices deflated with an index of nonagricultural prices, $P_{na}$ or $P^*_{na}$). Agricultural trade and price policies have resulted in greater price stability for producers of wheat, basmati and ordinary rice, cotton, sugar, maize, and milk. Only for vegetable oil and fertilizer are coefficients of variation of border prices calculated using equilibrium exchange rates approximately the same as or lower than coefficients of variation of actual domestic prices. For producers of wheat, rice, cotton, and maize, increased price stability is accompanied by lower average prices.

## Table 14—Coefficients of variation of producer prices, 1961-87

| Commodity | $P_p/P_{na}$ | $P'_p/P_{na}$ | $P^*_p/P^*_{na}$ |
|---|---|---|---|
| Wheat (import parity) | 0.11 | 0.57 | 0.42 |
| Wheat (export parity) | 0.11 | 0.48 | 0.29 |
| Basmati (unmilled)[a] | 0.12 | 0.46 | 0.22 |
| Basmati[a] | 0.09 | 0.39 | 0.21 |
| Ordinary rice (unmilled) | 0.12 | 0.67 | 0.44 |
| Ordinary rice | 0.12 | 0.63 | 0.42 |
| Cotton | 0.14 | 0.39 | 0.28 |
| Vegetable oil | 0.26 | 0.27 | 0.22 |
| Sugar (ex-mill) | 0.13 | 0.71 | 0.57 |
| Sugar cane | 0.17 | 1.17 | 0.80 |
| Maize | 0.15 | 0.54 | 0.40 |
| Milk[b] | 0.07 | 0.42 | 0.30 |
| Fertilizers | 0.26 | 0.36 | 0.27 |

Source: Author's calculations based on data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: $P_p/P_{na}$ is the actual relative price to producers. $P'_p/P_{na}$ is the border price for a farm product relative to actual prices of nonagricultural product. $P^*_p/P^*_{na}$ is the ratio of the border price of a farm product to the price of nonagricultural products with both prices measured using the equilibrium exchange rate.

[a] Prices for 1960/61-1962/63 are not included.

[b] Border prices for 1960/61-1970/71 are not included.

# 7

# MODELING THE REAL EFFECTS OF PRICE CHANGES

In this section, a model designed to estimate the effects of changes in agricultural prices on real variables such as production, consumption, and income is presented. The model incorporates tradable as well as nontradable goods and allows endogenous determination of supply and demand of all agricultural commodities, agricultural income, prices of nontraded goods, and the balance of trade for agricultural commodities.

Two simulations are conducted. The first simulates the effects of a policy of free trade in agriculture with no exchange rate adjustment. Domestic prices of traded goods are thus equal to border prices at actual historical exchange rates. The second simulation also examines the effects of a policy of free trade, with an adjustment for the macroeconomic effects of a different trade policy on the real exchange rate.[24] Domestic prices of tradable goods in the second simulation are equal to border prices at a counterfactual equilibrium exchange rate. The simulations project the effects of these policy scenarios on agricultural output, consumption, aggregate agricultural income, and the balance of trade for agriculture.

The main equations of the model are presented first and followed by a list of the definitions of the variables and parameters used. The algorithm used in solving the model is outlined briefly. Finally, the major differences between the new model and that used by Nabi, Hamid, and Nasim (1987) are highlighted, and remaining gaps in the model framework are discussed.

## Model Equations

The main equations of the agricultural model and definitions of the variables and parameters are presented here (see the glossary of variables on pages 60-61). Nine equations determine supply, consumption, income, and trade. Equations 27-34 define prices and marketing margins. Various identities are not included here. All domestic prices are expressed in real terms, using PNA(t) or PNA1(t), the historical and simulated price indices of nonagricultural goods and services, as price deflators.

### Supply

The supply equations are

$$\begin{aligned}\mathrm{LOG}[\mathrm{Area1}(t,i)/\mathrm{Area}(t,i)] &= \mathrm{ELAG}(i)\cdot \mathrm{LOG}[\mathrm{Area1}(t-1,i)/\mathrm{Area}(t-1,i)]\\ &\quad + \Sigma_j\,\mathrm{ESA}(i,j)\cdot \mathrm{LOG}[\mathrm{PPE1}(t,j)/\mathrm{PPE}(t,j)],\end{aligned} \tag{17}$$

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[24] Logically, the indirect effects on the real exchange rate of a free trade in agriculture policy (with no change in industrial trade policy) could have been simulated as well. However, the magnitude of these indirect effects are very small, given the small size of net agricultural trade restrictions (for example, export taxes on basmati rice and cotton with import restrictions on sugar and wheat) relative to total (agricultural and nonagricultural) trade.

$$\mathrm{LOG}[\mathrm{Yield1}(t,i)/\mathrm{Yield}(t,i)] = \Sigma_j\, \mathrm{EY}(i,j) \cdot \mathrm{LOG}[\mathrm{PPE1}(t,j)/\mathrm{PPE}(t,j)], \text{ and} \tag{18}$$

$$\mathrm{Prod1}(t,i) = \mathrm{Area1}(t,i) \cdot \mathrm{Yield1}(t,i). \tag{19}$$

In calculating supply effects, the impact of price changes on both acreage and yield is modeled. Acreage is modeled in a Nerlovian framework as a function of lagged acreage and expected farmgate crop prices (equation 17). Expected farmgate prices are assumed to equal a weighted average of actual farmgate prices in the previous three years (see equations 27 and 28), with weights declining for further back years.[25] Yield is assumed to depend only on expected farmgate crop prices (equation 18).

### Consumption

Consumption is calculated as a function of real consumer prices and income.

$$\begin{aligned} \mathrm{LOG}[\mathrm{Cons1}(t,i)/\mathrm{Cons}(t,i)] &= \mathrm{EDY}(i) \cdot \mathrm{LOG}[\mathrm{Y1}(t)/\mathrm{GNP}(t)] \\ &+ \Sigma_j\, \mathrm{ED}(i,j) \cdot \mathrm{LOG}[\mathrm{PC1}(t,j)/\mathrm{PC}(t,j)]. \end{aligned} \tag{20}$$

### Income

The income equations are as follows:

$$\mathrm{YAG}(t) = \Sigma_j\, \mathrm{PP}(t,i) \cdot \mathrm{Prod}(t,i), \tag{21}$$

$$\mathrm{YNAG}(t) = \mathrm{GNP}(t) - \mathrm{YAG}(t), \tag{22}$$

$$\mathrm{YAG1}(t) = \Sigma_j\, \mathrm{PP1}(t,i) \cdot \mathrm{Prod1}(t,i), \text{ and} \tag{23}$$

$$\mathrm{Y1}(t) = \mathrm{YAG1}(t) + \mathrm{YNAG}(t). \tag{24}$$

In calculating income, it is assumed that nonagricultural income remains unchanged relative to historical values. Agricultural income is calculated as simulated producer prices times the quantity produced (equation 23). Consumer prices of traded goods are simply border prices adjusted for marketing costs (equations 29 and 30).

### Trade

$$\mathrm{Trade1}(t,i) = \mathrm{Prod1}(t,i) \cdot [1 - \mathrm{XLOSS}(i)] - \mathrm{Cons1}(t,i), \text{ for all } i, \text{ except } i = 4, \text{ and} \tag{25}$$

$$\begin{aligned} \mathrm{Trade1}(t,i) &= \mathrm{Prod1}(t,4) \cdot [1 - \mathrm{XLOSS}(4)] - \mathrm{Cons1}(t,4) \\ &+ \mathrm{XOIL} \cdot [\mathrm{Prod1}(t,12)] \cdot [1 - \mathrm{XLOSS}(12)]. \end{aligned} \tag{26}$$

The model calculates the autarky (no trade) prices of nontraded goods, given income and the prices of traded goods, by solving a system of simultaneous equations. For nontraded goods, equation 30 is used to calculate producer prices received by farmers as the consumer prices less marketing costs.

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[25] Weights of 0.50, 0.35, and 0.15 for prices lagged 1 to 3 years are assumed.

## Glossary of Variables and Parameters Included in the Simulation Model

### Variables

The variables included in the simulation model are defined as follows:

Area(t,i) = Area of commodity i, year t, in 1,000 hectares.

Area(t,i) = Simulated area of commodity i, year t, in 1,000 hectares.

Cons(t,i) = Consumption of commodity i, year t, in 1,000 metric tons.

Cons1(t,i) = Simulated consumption of commodity i, year t, in 1,000 metric tons.

CPI(t) = Consumer price index, year t.

ER(t) = Nominal exchange rate, year t, Rs per US$.

GNP(t) = Gross national product, year t, in Rs billion.

Marg1t(t,i) = Marketing margin for commodity i from farmgate to processing center, year t, in Rs per kilogram of unprocessed commodity.

Marg2t(t,i) = Marketing margin for commodity i from processing center to wholesale market, year t, in Rs per kilogram of processed commodity.

Pbasm1(t) = Simulated f.o.b. price of basmati rice, Karachi, in US$ per metric ton before comparison with historical ordinary rice price levels.

Pbasm2(t) = Simulated f.o.b. price of basmati rice, Karachi, in US$ per metric ton.

Pbasmw(t) = f.o.b. price of basmati rice, Karachi, in US$ per metric ton.

PC(t,i) = Consumer price of commodity i at the wholesale level, year t, Rs per metric ton.

PC1(t,i) = Simulated consumer price of commodity i at the wholesale level, year t, Rs per metric ton.

PC1M(t,i) = Simulated import parity consumer price of commodity i at the wholesale level, year t, Rs per metric ton.

PC1X(t,i) = Simulated export parity consumer price of commodity i at the wholesale level, year t, Rs per metric ton.

Pordw(t) = f.o.b. price of ordinary rice, Bangkok, in US$ per metric ton.

PNA(t) = Price index of nonagricultural goods, year t.

PNA1(t) = Simulated price index of nonagricultural goods, year t.

PP(t,i) = Producer price of commodity i at the farmgate, year t, in Rs per metric ton.

PP1(t,i) = Simulated producer price of commodity i at the farmgate, year t, in Rs per metric ton.

PPE(t,i) = Expected producer price of commodity i at the farmgate, year t, in Rs per metric ton.

PPE1(t,i) = Simulated expected producer price of commodity i at the farmgate, year t, in Rs per metric ton.

Prod(t,i) = Production of commodity i, year t, in metric tons.

Prod1(t,i) = Simulated production of commodity i, year t, in metric tons.

SHIP(t) = Shipping costs from Karachi to the Middle East for basmati rice, year t, in US$ per metric ton.

Trade(t,i) = Trade of commodity i, year t, in metric tons (negative value indicates imports).

Trade1(t,i) = Simulated trade of commodity i, year t, in metric tons (negative value indicates imports).

XHAND(t) = Export handling costs of basmati rice, year t, in Rs per metric ton.

Y1(t) = Simulated gross national product, year t, in Rs billion.

YAG(t) = Gross value of major agricultural commodities in Rs billion.

YAG1(t) = Simulated gross value of major agricultural commodities, in Rs billion.

Yield(t,i) = Yield of commodity i, year t, in kilograms per hectare.

Yield1(t,i) = Simulated yield of commodity i, year t, in kilograms per hectare.

YNAG(t) = Gross national product less gross value of major agricultural commodities, in Rs billion.

**Parameters**

BSDIF = Minimum price differential between basmati and ordinary rice on the world market.

ED(i,j) = Elasticity of demand of commodity i with respect to a change in price of commodity j.

EDY(i) = Income elasticity of demand of commodity i.

EY(i,j) = Elasticity of yield of commodity i with respect to a change in price of commodity j.

ELAG(i) = Adjustment parameter on lagged area, commodity i.

ESA(i,j) = Short-run elasticity of area planted (or production) of commodity i, with respect to a change in price of commodity j.

MARG1(i) = Marketing margin for commodity i from farmgate to the processing center in 1987, in Rs per kilogram of unprocessed commodity.

MARG2(i) = Marketing margin for commodity i from the processing center to wholesale market in 1987, in Rs per kilogram of processed commodity.

PRATE(i) = Conversion factor: kilograms of processed commodity per kilogram of unprocessed commodity.

XLOSS(i) = Waste and storage losses of commodity i per metric ton of production.

XOIL = Rate of kilograms of cottonseed oil to kilograms of lint cotton.

### Prices

The price equations are

$$PPE(t,i) = 0.5 \cdot PP(t-1,i) + 0.35 \cdot PP(t-2,i) + 0.15 \cdot PP(t-3,i), \qquad (27)$$

$$PPE1(t,i) = 0.5 \cdot PP1(t-1,i) + 0.35 \cdot PP1(t-2,i) + 0.15 \cdot PP1(t-3,i), \qquad (28)$$

$$PC(t,i) = [PP(t,i) + Marg1(t,i)]/PRATE(i) + Marg2(t,i), \qquad (29)$$

$$PC1(t,i) = [PP1(t,i) + Marg1(t,i)]/PRATE(i) + Marg2(t,i), \qquad (30)$$

$$Marg1t(t,i) = Marg1(i) \cdot CPI(t)/CPI(1987), \qquad (31)$$

$$Marg2t(t,i) = Marg2(i) \cdot CPI(t)/CPI(1987), \qquad (32)$$

$$\begin{aligned} LOG[Pbasm1(t)] &= LOG[Pbasmw(t)] + (1/ELASB) \\ &\cdot [Trade1(t,4) - Trade(t,4)]/20{,}000, \text{ and} \end{aligned} \qquad (33)$$

$$Pbasm2(t) = \text{Maximum } [BSDIF \cdot Prodw(t), Pbasm1(t)]. \qquad (34)$$

For area and yield elasticities with respect to price, see Appendix 1, Table 29. For demand and income elasticities, see Appendix 1, Table 30. For all traded commodities except basmati rice, Pakistan is assumed to be a "small country" in the world market, so that changes in Pakistan's trade do not affect the world price. For basmati rice, for which Pakistan enjoys a monopoly on exports, world price is simultaneously determined with Pakistan's exports in the model. Based on parameter estimates from a regression of world demand for basmati rice (see Appendix 4), the world price of basmati rice is assumed to decline by 0.533 percent for every 20,000-ton increase in Pakistan's exports (equation 33). In addition, it is assumed that the world price for basmati rice will not fall to less than 1.6 times the world price for ordinary rice (5 percent broken) (equation 34).[26]

## Model Algorithm

1. For each commodity, area, yield, and production (equations 17, 18, and 19) are calculated as functions of expected producer prices (equations 27 and 28).
2. For each commodity, the realized producer price is set equal to the expected producer price and the consumer price is set equal to the expected producer price plus marketing costs (equations 29 and 30).
3. For each commodity, the trade status indicator is set to correspond with trade status in the previous year of the simulation (or with historical trade status in the first year of the simulation).
4. Agricultural and total incomes are calculated using realized producer prices and simulated production (equations 21-24).

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[26] In the period studied, the minimum ratio of prices of basmati rice to ordinary rice was approximately 1.6.

5. For each commodity, demand and trade are calculated using simulated consumer prices (equations 25, 26, and 27).
6. Consistency of trade status indicators and trade levels for each commodity are checked.
   - If the trade status indicator is "import parity" and imports are negative (trade is greater than zero), the trade status indicator is set to "nontraded."
   - If the trade status indicator is "export parity" and exports are negative (trade is less than zero), the trade status indicator is set to "nontraded."

   If no trade status indicators were changed in step 6, proceed to step 7; otherwise, to step 8.
7. Whether a solution has been found is determined. Error $= \Sigma_i$ [Trade (t,i)]$^2$ is calculated for goods i that have a "nontraded" status. If Error is less than maximum error (= 1.0), a solution has been found. Otherwise, proceed to step 8.
8. The matrix inversion subroutine is called to calculate autarky (no trade) consumer prices of all goods that are nontraded.
9. Autarky consumer prices of nontraded goods are compared with import and export parity prices.
   - If the autarky price is less than export parity, the consumer price is set to the export parity price and trade status is set to "export parity."
   - If the autarky price is greater than import parity, the consumer price is set to the import parity price and trade status is set to "import parity."
10. The world price of basmati rice and the new consumer price of basmati rice are calculated, given simulated exports of basmati rice (equations 33 and 34).
11. For each commodity, the new realized producer price equal to the new consumer price less marketing costs is calculated (equation 30).
12. Return to Step 4.

The trade status of each tradable good (whether the good is exported, imported or not traded) may change from year to year according to simulated domestic demand and supply and world prices. Four goods (sorghum/millet, pulses, meat, and fruit) are treated as nontradables; trade for each of these goods is fixed at zero. Milk is also modeled as a nontradable for years prior to 1972.

For each simulation year, domestic production is determined as a function of expected prices and lagged area; real income is calculated using the simulated levels of production and producer prices. Consumption and trade are then computed using consumer prices equal to producer prices plus marketing costs.

Before solving for equilibrium consumer prices of nontraded goods, trade levels of all tradable goods are checked for consistency with the consumer prices used. If exports (imports) are negative and export (import) parity prices of the commodity are used in calculating consumption and trade, the good is reclassified as a nontraded good. Autarky prices of all nontraded goods (the four commodities that are modeled as nontradable and tradable commodities with negative exports at export parity prices or negative imports at import parity prices) are calculated by solving a system of linear equations in the logarithms of the consumer prices.

The autarky prices of tradable goods are then compared with import and export parity prices. If the autarky price is greater than the import parity price (or less than the export parity price), the consumer price is set at the import (export) parity price. New export parity and consumer prices of basmati rice are also calculated using basmati rice trade levels.

The model iterates by recalculating consumption and trade levels using the new consumer prices. A solution of the model is reached when exports (imports) of all goods with export (import) parity consumer prices are positive and when the sum of squares of trade of nontraded commodities is small (less than 1.0). Producer and consumer prices are stored for the following year's simulation.

## Data

Domestic supply and demand elasticities are from Hamid et al. (1987) and are presented in Appendix 1, Tables 29 and 30. These own-price elasticities of demand are largely based on econometric estimates. Hamid et al. constructed the full matrix of demand parameters from these econometric estimates, making their own judgments on other elasticities and using constraints imposed by economic theory (symmetry of compensated cross-price elasticities, homogeneity, and an assumption that compensated cross-price elasticities between food and nonfood are zero). Area response parameters are calculated in a similar manner, with the important restriction that the aggregate area supply response for an index of agricultural prices is set at 0.25. This guarantees that the total change in area planted for all crops does not increase too greatly when prices of all crops increase. Changes in relative prices still result in changes in the area mix, and smaller changes in total area planted. In addition, nonzero cross-price elasticities of cotton yields with wheat prices and of wheat yields with cotton prices are specified to capture the trade-offs between these two crops in major production systems in the Punjab. [See Hamid et al. (1987) for more details.]

Marketing margins are based on those used in the calculations of nominal and effective rates of protection (see Appendix 2). Values of the other remaining parameters are given in Appendix 1, Tables 29 and 30.

## Overview of the Model

The model described above differs in a number of ways from that used by Nabi, Hamid, and Nasim (1987). Seven additional agricultural subsectors (maize, millet and sorghum, pulses, vegetable oils, meat, milk, and fruit) have been added to the five included in the Nabi, Hamid, and Nasim model (wheat, basmati rice, ordinary rice, sugarcane, and cotton). By endogenizing supply, demand, and prices of nontradables (millet and sorghum, pulses, meat, and fruit), the model is able to capture the effects of trade and exchange rate policies on nontradable agricultural commodities as well as tradables. Moreover, whether a tradable good is imported, exported, or not traded in a given simulation year is determined endogenously. Agricultural income and income effects on demand are included, as well as adjustments in the world price of basmati rice in response to changes in Pakistan's exports.

The models also differ in the parameter estimates used. Nabi, Hamid, and Nasim (1988) use supply elasticities from Tweeten (1985) for calculating changes in the value added of each subsector; the new model uses supply elasticities of Hamid et al. (1987) and calculates changes in real output. Both studies use demand parameters from Hamid et al. (1987).

Several important aspects of the response of agricultural supply and demand to changes in price incentives are not captured in the new model, however. Inputs to agricultural production are not explicit in the model framework because attempts to estimate supply functions that incorporate inputs proved unsuccessful. For variable inputs such as fertilizer, this omission is not of great importance. The model results can be interpreted in two ways, assuming either that technology for each crop is constant or that changes in purchases of fertilizer are small compared with changes in value of production calculated in the model. Constraints on price response due to rigidities in cropping patterns and crop rotations also are not modeled explicitly. These constraints are captured to some degree, however, by the cross-price elasticities for area planted and the cross-price elasticities in the cotton and wheat yield equations.

More serious is the absence of explicit price effects on agricultural investment and labor. As shown by Valdés, Hurtado, and Muchnik (1989), price-induced changes in agricultural investment and labor migration have had important long-run effects on agricultural production in Chile. Reduced price incentives discourage investment in agriculture and lessen the capital stock available for future production; low agricultural prices relative to nonagricultural prices reduce labor demand in agriculture as well as the value of output, making migration to urban areas a more attractive option for workers. These effects are also likely to be important in Pakistan, although the types of private investment in agriculture in Pakistan (such as tubewells, tractors, and land improvements for better drainage) differ from those modeled in Chile (stocks of cattle, orchards, and tractors). By including a long lag adjustment in area for fruit trees, the new Pakistan model captures some of the investment effect for this relatively small sector in Pakistan, but the effects of changes in the capital stock of tubewells and tractors for the annual crop sectors are not modeled. The model presented in this chapter should be considered as a short-to-medium-run model. To capture the longer-run effects of the changes in incentives would require an approach that captures the effects on private investment in agriculture and labor employment.

Moreover, the effects of government investment in agriculture (in particular, research and extension on new seeds, irrigation dams and canals, and rural infrastructure such as road and communication networks) are not captured in this framework. Public investment and capital is thus exogenous to the model.

What do these estimated output effects assume about public and private investment and about the elasticity of supply of inputs to agriculture? The parameters come from time series of actual values, but their estimation does not fully or explicitly capture the factor markets in agricultural production or government investment in agriculture. Implicitly, the model assumes a fairly elastic supply of fertilizers, electric power, tractors, new high-yielding varieties (HYVs), and so forth. Higher incentives allow more private capital to be invested in the use of these inputs. But they do not guarantee an elastic supply. To a large extent, except for HYVs, inputs are tradable, and appropriate trade policy should make their supply quite elastic. Public investment is, of course, a different story.

The output response of agricultural tradables implies a resource reallocation within agriculture and between agriculture and nonagriculture. The home-goods-producing sector and the protected industrial sector would, in the long run, release resources (mostly capital) toward the production of tradables. Determining the time path of this adjustment in a long-run context is beyond the scope of this study. The appropriate implicit supply response in agricultural tradables may seem too high. In this analysis, the elasticity of total supply with respect to a change in agricultural prices is equal to the sum of the area and yield elasticities. The area elasticity is constrained to a maximum value of 0.25, and the yield elasticity used is 0.35 (from Hamid et al. 1987); thus the total supply response is 0.60. Given no response of yield to prices for milk, meat, and fruit, and small cross-price effects on yields for wheat and cotton, the aggregate supply elasticity is approximately 0.45 to 0.50.

Finally, the effects of alternative trade policies on the industrial sector are necessarily ignored in this partial equilibrium analysis. Changes in tariffs, quotas, and exchange rates would have large effects on outputs of industrial and related sectors, which would induce changes in employment, incomes, demand for agricultural products, and labor and capital availability. Some of these effects may be of secondary importance from the perspective of the agricultural sector, but they are crucial to the industrial sector itself.

# 8

# REAL EFFECTS OF CHANGES IN PRICE INCENTIVES: SIMULATION RESULTS

In this chapter, the model presented in Chapter 7 is used to simulate the real effects of changes in price incentives during 1961-87. Two simulations are conducted with prices of traded goods determined by border prices. In the first simulation, border prices, based on free trade, are calculated using historical exchange rates. The second simulation uses border prices based on free trade at equilibrium real exchange rates.

The assumptions for the simulations are outlined first. After an overview of the major simulation results, more detailed descriptions of the effects on each commodity are given. The effects of the simulated change in policy on aggregate agricultural income and the balance of trade are also presented. Finally, the simulated effects on the government budget are compared with those of other recent studies addressing the issue of the extent to which agriculture in Pakistan has been taxed.

## The Price Policy Simulations

Simulation 1 (free trade with no exchange rate adjustment) models the direct effects of agricultural price policies; simulation 2 (free trade at equilibrium real exchange rates) includes both the direct and indirect effects of exchange rate and trade policies on prices and real variables. Both simulations assume free trade in agricultural products and no government interference in domestic prices. Prices received by producers of traded goods thus are equal to export parity in years in which the goods are exported and equal to import parity in years in which the goods are imported. For years in which domestic supply and demand equilibrates at a price between export and import parities, this autarky (no trade) price is the producer price. Consumer prices are determined in a completely analagous fashion.

A free-trade policy is chosen for these simulations as a reference scenario and because it is suggestive of the gains from trade. This does not mean that absolute free trade is essential for economic prosperity. Certainly, free trade does not benefit everyone, unless the losers can be fully compensated. The results of these simulations, however, provide a comparison with the complex mix of market interventions that have been used by various Pakistani governments to alter producer and consumer prices.

A few characteristics of the policy simulations should be noted. The input data for the simulations include historical levels of production, consumption, trade, and prices, and the border prices for producers and consumers used in the calculations of direct and total effects of trade and exchange rate policies in Chapter 6. In the simulations all domestic prices are deflated by the price index of nonagricultural commodities. In simulation 1, $P_{na}$ (the price index of nonagricultural commodities) is unchanged from its historical level, because only agricultural trade and price policies are assumed to have changed. In simulation 2, $P^{*}_{na}$, which incorporates the effects of changes in exchange rates and trade policies on nonagricultural prices, is used as the price deflator for simulated prices ($P_{na}$ is still used to deflate historical prices). In both simulations, it is implicitly assumed that the average price of nontradables in the economy is unchanged from the historical levels.

Procurement prices are used as the historical expected producer prices for basmati and ordinary rice, sugarcane, and cotton for all years of the simulation. Because wheat procurement was small in the years between 1961 and 1968, procurement prices for wheat are used as the historical expected producer price only for years after 1967. For wheat prior to 1968 and for all other goods, historical expected producer prices are a weighted average of past market prices.

Milk is modeled as a nontraded good prior to 1972 because of lack of data on prices of imported milk products for these years. Fruits are modeled as nontraded goods in every year, even though Pakistan has exported some citrus products in recent years, because adequate data on prices of exported and domestic citrus products are unavailable.

## Overview of Simulation Results: Three Subperiods

### 1961-71

In the 1961-71 period, agricultural trade and price policies helped offset the negative protection of agricultural tradables caused by the overvalued exchange rate. Nominal rates of protection measured at the official exchange rate were positive for wheat, ordinary rice, cotton, vegetable oil, sugar, and maize. Only for basmati rice were the direct effects of trade and agricultural price policies negative. Thus, with free trade and no change in the exchange rate as in simulation 1 (Appendix 5, Tables 34 and 35), prices of most agricultural commodities would have declined.

For the 1960s, free trade in agricultural products would have destroyed producer incentives for sugar: expected producer prices and production would have fallen by more than 80 percent.[27] The shift out of sugarcane limits the effect of reduced producer prices for other crops, though; despite a drop in expected producer prices of 18 percent for wheat and 40 percent for cotton, annual production of the two crops is reduced by only about 10 percent. According to the simulation, production of basmati rice would have increased by 47 percent in 1961-71 if the export tax and other marketing restrictions had been removed (see Tables 15 and 16).

With free trade in agriculture and a free-trade equilibrium exchange rate (simulation 2, Appendix 5, Tables 36 and 37), prices of most agricultural commodities would have increased sharply. As a result, in the 1966-71 period, there would have been large increases in the production of wheat (28 percent), maize (51 percent), ordinary rice (77 percent), vegetable oil (42 percent), and cotton (54 percent). Production of basmati rice would have more than doubled. But production of sugar still would have fallen (by 37 percent) in this period.

### 1972-77

High world prices of most agricultural commodities in the early 1970s, coupled with Pakistan's nominal exchange rate devaluation in 1972, sharply raised the border prices of agricultural commodities measured at the official exchange rate. Beginning in 1974, simulated expected producer prices of all traded commodities would have risen sharply (except for milk prices in a few years). Production of wheat would have

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[27] The simulation results for the two subperiods, 1961-71 and 1972-87, for production, consumption, and trade are summarized in Table 18. For details of these results see Appendix 5, Tables 34 through 37. The percentage changes shown in Table 15 and other tables reporting simulation results show the average values that would have prevailed if direct and total price interventions were removed. The percentage changes given are relative to the historical values of the variables.

## Table 15—Direct and total effects of trade and exchange rate policies on agricultural production and consumption, 1961–71 and 1972-87

| Subsector/ Commodity | 1961-71 | | | | 1972-87 | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct Effects (Simulation 1) | | Total Effects (Simulation 2) | | Direct Effects (Simulaion 1) | | Total Effects (Simulation 2) | |
| | (1,000 metric tons) | (percent change) | (1,000 metric tons) | (percent change) | (1,000 metric tons) | (percent change) | (1,000 metric tons) | (percent change) |
| Production | | | | | | | | |
| Wheat | 4,613.2 | -7.28 | 6,284.6 | 22.87 | 12,252.9 | 20.11 | 14,231.0 | 43.29 |
| Basmati | 582.2 | 46.75 | 1,115.2 | 170.31 | 1,126.6 | 44.76 | 1,288.7 | 72.55 |
| Other rice | 1,149.0 | 5.39 | 1,757.7 | 55.53 | 2,957.4 | 36.61 | 3,545.6 | 65.58 |
| Sugarcane | 6,938.2 | -60.04 | 14,892.5 | -20.37 | 27,602.5 | 1.10[a] | 35,409.2 | 32.47 |
| Cotton | 398.6 | -6.50 | 651.3 | 48.61 | 760.1 | 0.72 | 941.4 | 28.14 |
| Milk | 6,668.7 | -4.49 | 7,495.0 | 6.73 | 6,458.7 | -29.53 | 8,093.3 | -11.13 |
| Consumption | | | | | | | | |
| Wheat | 5,282.0 | -0.40 | 5,087.6 | -4.99 | 9,084.8 | -10.89 | 8,829.9 | -12.31 |
| Basmati | 248.2 | -8.42 | 222.8 | -18.07 | 450.8 | 0.29 | 462.5 | 8.98 |
| Other rice | 930.5 | 1.75 | 856.4 | -8.47 | 1,264.0 | -3.11 | 1237.9 | -5.15 |
| Sugarcane | 2,410.0 | 61.48 | 2146.7 | 41.74 | 2,905.0 | 27.63 | 2852.2 | 27.25 |
| Cotton | 252.2 | -3.62 | 195.0 | -26.95 | 428.1 | -1.20 | 422.0 | -2.07 |
| Milk | 6,001.6 | -5.29 | 6,745.5 | 5.85 | 11,247.3 | 31.27 | 10,812.2 | 27.97 |

Source: Historical data are from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The values in absolute terms represent the average values for the subsectors that would have prevailed if direct and total price interventions were removed. The percentage changes are relative to the historical values of these subperiods.

[a] The increase in production of sugarcane in spite of the removal of protection reflects the lag in the producers response to the fall in world sugar prices in 1982 and 1987, so that, in effect, for these years, sugarcane was taxed (see Appendix 5, Table 36 for five-year averages).

**Table 16—Direct and total effects of trade and exchange rate policies on agricultural trade, 1961-71 and 1972-87**

| Commodity | 1961-71 Simulation 1 | 1961-71 Simulation 2 | 1961-71 Historical | 1972-87 Simulation 1 | 1972-87 Simulation 2 | 1972-87 Historical |
|---|---|---|---|---|---|---|
| | (1,000 metric tons) | | | (1,000 metric tons) | | |
| Wheat | −1,130.2 | 868.5 | −785.3 | 1,942.8 | 3,978.0 | −930.5 |
| Basmati | 275.9 | 780.9 | 88.7 | 563.2 | 697.3 | 257.2 |
| Other rice | 103.6 | 725.1 | 43.3 | 1,397.7 | 1,953.2 | 645.6 |
| Sugarcane | −1,879.6 | −1,014.8 | −34.4 | −746.9 | − 86.1 | −27.2 |
| Cotton | 106.5 | 391.2 | 124.6 | 255.9 | 425.2 | 228.9 |
| Milk | 0.2 | 0.1 | −52.6 | −5,434.6 | −3,528.8 | −139.4 |

Source: Historical trade data are from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

increased by 28 percent, largely due to a 19 percent increase in yields. Sugar production would have more than doubled in 1976 and 1977, relative to its historical level, as expected producer prices reach 250 percent of historical procurement prices. Production of both basmati and ordinary rice would have increased by nearly 59 percent, but cotton production actually would ~~have fallen~~ by 10 percent relative to historical levels, despite a modest increase in expected producer prices because of negative cross-price effects from high wheat, sugarcane, and rice prices (see Appendix 5, Table 34).

This rosy scenario for agricultural producers has rather disturbing implications for consumers, however. Despite the 10 percent increase in incomes in the rural sector, and assuming that urban nominal wages are unchanged, consumer prices of wheat would have increased by 77 percent and ordinary rice prices by 101 percent. Consequently, consumption of these commodities would have fallen by about 10 percent. To the extent that higher food prices are partly transmitted to urban wages, these consumption effects would change. Consumption of basmati rice and sugar would have increased, however, because increased prices of other staples and increased incomes would have outweighed the effects of increases in consumer prices in basmati rice (see Appendix 5, Table 35).

Similarly, under free trade and equilibrium exchange rates (simulation 2), higher agricultural prices of traded goods would have encouraged large increases in production and net trade at the cost of lower consumption and higher consumer prices (see Appendix 5, Tables 36 and 37). Production of all major commodities would increase: wheat (64 percent), basmati rice (103 percent), ordinary rice (95 percent), sugarcane (84 percent), and cotton (31 percent) (Appendix 5, Table 36).

### 1978-87

In the 1978-87 period, the effects of moving to a policy of free trade in agricultural goods would have been less pronounced than in the 1972-77 period because world prices of most agricultural commodities had fallen back to levels more in line with long-term trends. Nevertheless, in simulation 1 in 1983-87, higher border prices would have resulted in an increase in expected wheat producer prices of about 30 percent and an increase in production of 11 percent over historical levels. Consumer prices for wheat also would have increased by almost 38 percent, so that wheat consumption would have fallen by 11 percent. Average production of basmati rice in the 1978-82 and 1983-87 periods would have increased by 33 and 42 percent, respectively, but the drop in world prices of ordinary rice would have limited the increase in its production to 9 percent in 1983-87. Border prices for sugar also fluctuated greatly; they were somewhat higher than historical procurement prices in 1978-82, but fell sharply after 1982 so that simulated sugar production is more than 44 percent lower than historical levels in 1983-87. Free trade in powdered milk would have reduced consumer prices of milk by almost 40 percent and expected producer prices by 60 percent, so that milk production would have decreased by 41 percent in 1983-87 and milk consumption would have increased by 27 percent (see Appendix 5, Tables 34 and 35).

Under free trade and an equilibrium exchange rate (simulation 2), wheat production in 1983-87 would have increased by 24 percent, consumer prices for wheat would have increased by 58 percent, and consumption of wheat would have declined by 12 percent. The increases in average 1983-87 production of maize (29 percent), basmati rice (52 percent), ordinary rice (29 percent), vegetable oil (100 percent), and cotton (29 percent) would also have been large (see Appendix 5, Table 36). Real incomes are essentially unchanged for the period as a whole (and are even slightly lower in 1986 and 1987) because of a large decline in prices and output of milk and sugar.

## Effects on Agricultural Income and the Balance of Trade

Tables 17 and 18 summarize the effects of the two alternative policy scenarios on total agricultural income and the balance of trade. Under simulation 1 (free trade in agricultural products with no exchange rate adjustment), income would have been lowered by 6 to 8 percent in the 1960s because of reduced producer prices and output for most agricultural commodities. During the 1972-77 period of high world prices and, after 1972, a devalued rupee, incomes would have been 12 percent higher because of large increases in production and prices of traded agricultural goods (Table 17). Historically, in the late 1970s, world prices fell; thus, the positive effect on income of increasing domestic prices to the level of free-trade prices would have been diminished. Lower incomes for producers of sugarcane and especially milk would have outweighed the small increases in value of other commodities. In 1983-87, total income would have been reduced by 5 percent.

**Table 17—Effects on agricultural income of simulated policy changes, 1961-87**

| | Simulation 1 | | Simulation 2 | |
|---|---|---|---|---|
| Period | Agricultural Income | Change | Agricultural Income | Change |
| | (Rs billion) | (percent) | (Rs billion) | (percent) |
| 1961-65 | 21.5 | -6.48 | 26.3 | 14.41 |
| 1966-71 | 37.6 | -8.06 | 47.6 | 16.51 |
| 1972-77 | 114.4 | 12.14 | 139.9 | 37.04 |
| 1978-82 | 262.2 | 0.93 | 284.3 | 9.43 |
| 1983-87 | 492.6 | -5.07 | 514.3 | -0.89 |
| 1961-87 | 177.5 | -1.48 | 194.4 | 7.88 |

Source: Historical trade data are from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

## Table 18—Effects of simulated policy changes on the balance of trade and on world basmati rice prices, 1961-87

| | | Simulation 1 | Simulation 2 | Simulation 1 | | Simulation 2 | |
|---|---|---|---|---|---|---|---|
| Period | Historical Trade Value | Trade Value | Trade Value | Price of Basmati Rice | Change | Price of Basmati Rice | Change |
| | | (Rs billion) | | (US$/metric ton) | (percent) | (US$/metric ton) | (percent) |
| 1961–65 | 2,400.13 | –154.70 | 139.48 | 215.54 | –13.71 | 180.11 | –27.90 |
| 1966–71 | –1,131.16 | –236.04 | 338.10 | 208.69 | –11.33 | 202.52 | –13.95 |
| 1972–77 | –6,093.85 | 465.78 | 1,471.39 | 377.36 | –18.28 | 345.63 | –25.15 |
| 1978–82 | –120.58 | –34.82 | 1,084.78 | 542.94 | –18.31 | 500.66 | –24.67 |
| 1983–87 | –688.34 | –796.75 | 189.52 | 457.41 | –30.51 | 420.21 | –36.16 |
| 1961–87 | –324.43 | –131.59 | 663.92 | 355.40 | –20.34 | 325.70 | –27.00 |

Sources: Historical trade data are from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years); and Dee-Cheok Cheong, *Terms of Trade and the Role of Government in Pakistan's Agriculture*, World Bank Staff Working Paper 34 (Washington, D.C.: World Bank, 1964).

Under simulation 2 (free trade in agricultural products with an equilibrium exchange rate), total agricultural income would have been dramatically higher—about 15 percent higher in the 1960s and 37 percent higher in the early 1970s. As in simulation 1, lower world prices of most commodities would have reduced the positive effects of free-trade price policy from 1978 to 1987. The drop in the value of production of sugarcane and milk is approximately the same as the gain in the value of production of other commodities, so that income would have fallen by only 1 percent in 1986 and 1987.

With free trade and no change in the exchange rate (simulation 1), Pakistan's balance of trade in agricultural products would have deteriorated in every period except 1972-77, when world prices for agricultural commodities were high (Table 18). In the 1960s, increased exports of basmati rice and decreased imports of vegetable oil would have been outweighed by larger imports of wheat and sugar. In the 1978-87 period, wheat would have become an export good and the volume of exports of basmati and ordinary rice would have increased by 117 and 68 percent, respectively, but a decline in world basmati rice prices, averaging about 25 percent (due to increased exports by Pakistan), and a large increase in milk imports from about 2.5 million tons per year to nearly 7 million tons (liquid milk equivalent) per year would have reversed the net effect on the balance of trade in agricultural products (see Appendix 5, Table 35).

Using equilibrium exchange rates in simulation 2 improves the balance of trade for traditional exports (cotton, basmati rice, and ordinary rice) in every period. The increase in rice exports is mainly due to a sharp increase in production in 1978-87 (55 percent for basmati and 48 percent for ordinary rice) (Appendix 5, Table 36). The consumption response (a 9 percent decrease) would have been more significant in expanding cotton exports, but the 27 percent increase in production still would have been the main determinant. In the case of milk, a substantial drop in production of 25 percent and a large increase in consumption of 25 percent account for the large increase in imports from 4.5 to 4.7 million tons in liquid milk equivalent per year (about 40 percent of total domestic consumption). Under this pricing scenario, the response of wheat production would have been very large—a 31 percent increase; this, coupled with a decrease in consumption of 13 percent, would have turned wheat into a major export, averaging almost 4 million tons per year of exports, about one-fourth of production (see Appendix 5, Table 37).

## Effects on Nontraded Goods

In the model simulations, changes in the demand and supply of nontraded goods are mainly determined by cross-price and income effects. As expected prices of competing crops increase (decrease), production of nontraded goods decreases (increases). Similarly, as prices of substitute goods increase (decrease), demand for nontraded goods increases (decreases). Whether equilibrium prices of nontraded goods rise or fall depends on the magnitudes of the cross-price elasticities of supply and demand and the income elasticity of demand.

For example, in simulation 1, lower prices of most traded goods would have led to lower incomes in the 1961-71 period, and both demand for meat and equilibrium meat prices would have fallen. In 1978-87, lower milk prices also would have hurt meat producers by discouraging production, while a decline in incomes would have reduced the demand for meat. Again, equilibrium meat prices would have fallen, although in this case supply-side effects play an important role. The price policy effects on other nontraded goods can be analyzed in a similar manner. Because cross-price effects on demand and supply are generally small, the simulated changes in equilibrium prices, production, and consumption of nontraded goods are likewise smaller in size than changes in these variables for traded goods (see Appendix 5, Tables 34 and 35).

## Measures of Total Taxation of Agriculture

The above simulations of alternative price policies provide a measure of the transfers into and out of agriculture as the result of government trade and pricing policies. By combining these measures of indirect taxation with data on actual levels of direct taxation of agriculture (land and income taxes) and with data on subsidies and taxes, estimates of total net taxation of agriculture are constructed (Table 19). Similar estimates of total net taxation of agriculture have also been constructed by Nabi, Hamid, and Nasim (1987 and 1988) and Qureshi (1988). To facilitate comparison of results, Tables 20 and 21 present the estimates of these studies in the same table format as Table 19.

The estimates for direct taxes, open input subsidies, and concealed input subsidies in Table 19 are taken from Qureshi (1988) and reproduced in Table 21 with a few slight modifications. Direct taxes include the land revenue tax, the agricultural income tax, and the *usher* (a levy collected from Muslim landowners and leaseholders, introduced in 1982, which is equal to about 5 percent of the value of output).[28]

Total open subsidies include subsidies on fertilizer,[29] tubewells (subsidy rate per tubewell installed), plant protection (free spraying of pesticides on farmland), and seeds. The estimates for open subsidies in Table 19 again follow the definitions used by Qureshi and differ only slightly from those of Table 21.[30]

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[28] Nabi, Hamid, and Nasim (1987) used a different source for the land revenue tax and omitted agricultural income taxes and the *usher* from their estimates. The Qureshi (1988) estimates of direct taxes in the 1980-83 period average Rs 45 million (about 20 percent) more than the Nabi, Hamid, and Nasim (1987) estimates.

[29] Domestic and imported fertilizers are both subsidized. The subsidy covers marketing costs and any costs in excess of the ceiling sales prices set by the government. Part of the subsidy accrues to fertilizer producers who receive a price higher than the border price; therefore, the series in Table 18 overstates the subsidy to farmers.

[30] The Nabi, Hamid, and Nasim (1987) estimates differ more significantly because the revenue collected from the surcharge levied on the low cost producers is subtracted from the subsidy on fertilizers. For the 1980-83 period, the Nabi, Hamid, and Nasim (1987) estimates exceed the new estimates by an average of Rs 313 million (16 percent).

# Table 19—Net transfers to agriculture from direct price and nonprice-related transfers for five commodities, based on model simulations, 1973-87

| Year/ Period | Total Direct Taxes (1) | Total Open Subsidies[a] (2) | Total Concealed Subsidies (3) | Subtotal for Net Subsidies to Producers (1)+(2)+(3) (4) | Total Indirect Taxes[b] (5) | Total Net Subsidies to Producers (4)+(5) (6) | Transfers Due to Output Price Interventions (Direct)[c] (7) | Subtotal for Price Intervention Effects (4)+(7) (8) | Public Investment in Research and Extension (9) | Total Price and Nonprice-Related Transfers (8)+(9) (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (Rs million) | | | | |
| 1973 | -167 | 441 | 40 | 314 | -712 | -398 | -12,158 | -11,844 | 1,598 | -10,246 |
| 1974 | -201 | 203 | 21 | 23 | -704 | -681 | -30,609 | -30,586 | 2,380 | -28,206 |
| 1975 | -232 | 454 | 339 | 561 | -692 | -131 | -28,652 | -28,090 | 3,127 | -24,963 |
| 1976 | -266 | 897 | 374 | 1,005 | -826 | 179 | -19,833 | -18,828 | 3,501 | -15,327 |
| 1977 | -136 | 920 | 394 | 1,178 | -372 | 806 | -10,741 | -9,563 | 4,433 | -5,130 |
| 1978 | -125 | 1,009 | 364 | 1,248 | -471 | 777 | -10,560 | -9,312 | 3,471 | -5,840 |
| 1979 | -291 | 1,991 | 389 | 2,089 | -247 | 1,842 | -14,981 | -12,892 | 4,391 | -8,501 |
| 1980 | -175 | 2,723 | 344 | 2,892 | -1,015 | 1,877 | -27,719 | -24,827 | 4,298 | -20,529 |
| 1981 | -227 | 2,479 | 680 | 2,932 | -1,860 | 1,072 | -24,316 | -21,384 | 5,934 | -15,450 |
| 1982 | -287 | 1,826 | 936 | 2,475 | -348 | 2,127 | -10,352 | -7,877 | 6,332 | -1,545 |
| 1983 | -427 | 1,980 | 932 | 2,485 | -1,410 | 1,075 | -11,679 | -9,195 | 7,869 | -1,326 |
| 1984 | -465 | 1,466 | 1,455 | 2,456 | -1,036 | 1,420 | -7,104 | -4,648 | 9,000E | 4,352 |
| 1985 | -505 | 1,501 | 2,220 | 3,216 | -878 | 2,338 | -5,190 | -1,974 | 10,000E | 8,026 |
| 1986 | -460 | 2,424 | 2,366 | 4,331 | 1,002 | 5,333 | 1,673 | 6,004 | 10,100E | 16,104 |
| 1987 | -365 | 2,044 | 3,250 | 4,929 | 1,526 | 6,455 | 1,328 | 6,257 | 10,300E | 16,557 |
| Average | | | | | | | | | | |
| 1973-77 | -201 | 583 | 234 | 616 | -661 | -45 | -20,399 | -19,782 | 3,008 | -16,775 |
| 1978-82 | -221 | 2,006 | 543 | 2,327 | -788 | 1,539 | -17,586 | -15,258 | 4,885 | -10,373 |
| 1983-87 | -445 | 1,883 | 2,045 | 3,483 | -159 | 3,324 | -4,195 | -711 | 9,454 | 8,742 |
| 1973-87 | -289 | 1,491 | 940 | 2,142 | -536 | 1,606 | -14,060 | -11,917 | 5,782 | -6,135 |

Sources: Columns (1), (2), (3), and (5) are from Sarfraz Khan Qureshi, "Prices, Taxes, and Subsidies: A Further Analysis of Issues Affecting Agricultural Sector of Pakistan," Pakistan Institute of Development Economics, Islamabad, 1988 (mimeo). Column (9) is from Ijaz Nabi, Nawed Hamid, and Anjum Nasim, "A Comparative Study of the Political Economy of Agricultural Pricing Policies: The Case of Pakistan," Revised Version, a paper prepared for the World Bank, Washington, D.C., 1988 (mimeo). Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: A minus sign indicates a transfer out of agriculture. E indicates an estimated amount.

[a] For years 1977, 1978, 1980, 1984, 1985, figures were changed from Qureshi's paper to reflect the data from the *Economic Survey*.

[b] Indirect taxes (export duties and corporation profits on rice and cotton and cesses on sugarcane and cotton) are not separately added in the subtotals (8) and (10) because they are already reflected in the transfers from output price interventions.

[c] Excludes input price interventions because they are included under (2).

## Table 20—Net transfers to agriculture from direct price and nonprice-related transfers, adapted from Nabi, Hamid, and Nasim (1987), 1973-87

| Year/ Period | Total Direct Taxes (1) | Total Open Subsidies (2) | Total Concealed Subsidies (3) | Subtotal for Net Subsidies to Producers (1)+(2)+(3) (4) | Total Indirect Taxes[a] (5) | Total Net Subsidies to Producers (4)+(5) (6) | Transfers Due to Output Price Interventions (Direct) (7) | Subtotal for Price Intervention Effects (4)+(7) (8) | Public Investment in Research and Extension (9) | Total Price and Nonprice-Related Transfers (8)+(9) (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (Rs million) | | | | |
| 1973 | -168 | 365 | -23 | 174 | -570 | -396 | -10,162 | -9,988 | 1,598 | -8,390 |
| 1974 | -180 | 32 | -30 | -178 | -643 | -821 | -34,849 | -35,027 | 2,380 | -32,646 |
| 1975 | -182 | 161 | 112 | 91 | -1,637 | -1,546 | -47,538 | -47,447 | 3,127 | -44,320 |
| 1976 | -259 | 552 | 219 | 512 | -1,172 | -660 | -32,451 | -31,939 | 3,501 | -28,437 |
| 1977 | -136 | 325 | 252 | 441 | -760 | -319 | -25,343 | -24,902 | 4,433 | -20,469 |
| 1978 | -125 | 806 | 252 | 933 | -687 | 246 | -25,953 | -25,019 | 3,471 | -21,548 |
| 1979 | -290 | 1,832 | 387 | 1,929 | -789 | 1,140 | -31,982 | -30,053 | 4,391 | -25,663 |
| 1980 | -172 | 2,566 | 588 | 2,982 | -538 | 2,444 | -39,198 | -36,215 | 4,298 | -31,917 |
| 1981 | -227 | 2,109 | 793 | 2,675 | -1,380 | 1,295 | -49,307 | -46,632 | 5,934 | -40,698 |
| 1982 | -286 | 1,465 | 1,001 | 2,180 | -527 | 1,653 | -45,824 | -43,644 | 6,332 | -37,312 |
| 1983 | -249 | 1,613 | 1,205 | 2,569 | -812 | 1,757 | -39,349 | -36,780 | 7,869 | -28,911 |
| 1984 | ... | 629 | 1,402 | 2,031 | -558 | 1,473 | 2,031 | ... | 9,000[b] | ... |
| 1985 | ... | ... | ... | ... | ... | ... | ... | ... | 10,000[b] | ... |
| 1986 | ... | ... | ... | ... | ... | ... | ... | ... | 10,100[b] | ... |
| 1987 | ... | ... | ... | ... | ... | ... | ... | ... | 10,300[b] | ... |
| Average | | | | | | | | | | |
| 1973-77 | -185 | 287 | 106 | 208 | -956 | -748 | -30,069 | -29,860 | 3,008 | -26,852 |
| 1978-82 | -220 | 1,756 | 604 | 2,140 | -784 | 1,356 | -38,453 | -36,313 | 4,885 | -31,427 |
| 1983-87 | -249 | 1,121 | 1,304 | 2,300 | -685 | 1,615 | -39,349 | -17,374 | 9,454 | -28,911 |
| 1973-87 | -207 | 1,038 | 513 | 1,362 | -839 | 522 | -34,723 | -30,468 | 5,782 | -29,119 |

Source: Adapted from Ijaz Nabi, Naved Hamid, and Anjum Nasim, "A Comparative Study of the Political Economy of Agricultural Pricing Policies: The Case of Pakistan," report prepared for the World Bank, Washington, D.C., 1987 (mimeo).

[a] Indirect taxes (export duties and corporation profits on rice and cotton and cesses on sugarcane and cotton) are not separately added in the subtotals (8) and (10) because they are already reflected in the transfers from output price intervention.

[b] These values are estimated from the revised 1988 version of the Nabi, Hamid, and Nasim paper cited above, Table 4.14.

## Table 21—Net transfer to agriculture from direct price and nonprice-related transfers, adapted from Qureshi (1988) for five commodities, 1973-87

| Year/ Period | Total Direct Taxes (1) | Total Open Subsidies (2) | Total Concealed Subsidies (3) | Subtotal for Net Subsidies to Producers (1)+(2)+(3) (4) | Total Indirect Taxes (5) | Total Net Subsidies to Producers (4)+(5) (6) | Transfers Due to Output Price Interventions (Direct) (7) | Subtotal for Price Intervention Effects (4)+(7) (8) | Total Price Intervention Effects (9) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (Rs million) | | | | |
| 1973 | -167 | 441 | 40 | 314 | -712 | -398 | -847 | -533 | -533 |
| 1974 | -201 | 203 | 21 | 23 | -704 | -681 | -6,873 | -6,850 | -6,850 |
| 1975 | -232 | 454 | 339 | 561 | -692 | -131 | -6,450 | -5,889 | -5,889 |
| 1976 | -266 | 897 | 374 | 1,005 | -826 | 179 | -4,665 | -3,660 | -3,660 |
| 1977 | -136 | 562 | 394 | 820 | -372 | 448 | -2,105 | -1,285 | -1,285 |
| 1978 | -125 | 1,026 | 364 | 1,265 | -471 | 794 | -8,561 | -7,296 | -7,296 |
| 1979 | -291 | 1,991 | 389 | 2,089 | -247 | 1,842 | -118 | 1,971 | 1,971 |
| 1980 | -175 | 2,721 | 344 | 2,890 | -1,015 | 1,875 | -1,479 | 1,411 | 1,411 |
| 1981 | -227 | 2,479 | 680 | 2,932 | -1,860 | 1,072 | -7,105 | -4,173 | -4,173 |
| 1982 | -287 | 1,826 | 936 | 2,475 | -348 | 2,127 | -1,867 | 608 | 608 |
| 1983 | -427 | 1,980 | 932 | 2,485 | -1,410 | 1,075 | -5,165 | -2,680 | -2,680 |
| 1984 | -465 | 1,482 | 1,455 | 2,472 | -1,036 | 1,436 | -5,551 | -3,079 | -3,079 |
| 1985 | -505 | 1,517 | 2,220 | 3,232 | -878 | 2,354 | -2,625 | 607 | 607 |
| 1986 | -460 | 2,424 | 2,366 | 4,331 | 1,002 | 5,333 | 4,585 | 8,916 | 8,916 |
| 1987 | -365 | 2,044 | 3,250 | 4,929 | 1,526 | 6,455 | 900 | 5,829 | 5,829 |
| Average | | | | | | | | | |
| 1973-77 | -201 | 511 | 234 | 545 | -661 | -117 | -4,188 | -3,644 | -3,644 |
| 1978-82 | -221 | 2,009 | 543 | 2,330 | -788 | 1,542 | -3,826 | -1,496 | 1,496 |
| 1983-87 | -445 | 1,889 | 2,045 | 3,490 | -159 | 3,330 | -1,571 | 1,918 | 1,918 |
| 1973-87 | -289 | 1,470 | 940 | 2,121 | -536 | 1,585 | -3,195 | -1,074 | -1,074 |

Source: Adapted from Sarfraz Khan Qureshi, "Prices, Taxes, and Subsidies: A Further Analysis of Issues Affecting Agricultural Sector of Pakistan," Pakistan Institute of Development Economics, Islamabad, 1988 (mimeo).

Notes: Public investment and research extension figures are not included in Qureshi. The five commodities included are wheat, basmati rice, ordinary rice, sugarcane, and cotton.

The estimates of concealed subsidies in Table 19 are also those of Qureshi (see Table 21). Concealed subsidies include subsidies on irrigation water (the difference between operating and maintenance expenses and the irrigation receipts),[31] agricultural credit (the difference between noninstitutional and institutional rates, estimated to be 9 percent), and electricity (the difference between cost and sale price times consumption of electricity). The estimates of concealed subsidies by Nabi, Hamid, and Nasim (1987) do not include electricity subsidies and they also differ because Nabi, Hamid, and Nasim use a different credit subsidy rate (4 percent up to 1971/72, 5 percent from 1972/73 to 1976/77, and 7 percent from 1978/79 to date).

Indirect taxes on agriculture (Table 19, column 5) include export duties on rice and cotton, profits of the rice and cotton export corporations, and cotton and sugarcane cesses (taxes). Data from Nabi, Hamid, and Nasim differ slightly because they do not include the cotton and sugarcane cesses, and estimates on profits from export corporations are higher than those of Qureshi. Thus the series for net subsidies (Table 19, column 6) are essentially the same as those of Qureshi but is somewhat higher than the Nabi, Hamid, and Nasim series, mainly because of the difference in estimating fertilizer subsidies.

Agriculture has provided relatively little actual tax revenue in Pakistan. Total tax revenues, including direct taxes (column 1 in Table 19) and indirect taxes (column 5) averaged Rs 1 billion at their peak in 1978-82, but this represented only 2.6 percent of total government revenues. In more recent years, tax revenues from agriculture fell further as lower world prices for rice and cotton changed export tax revenues to net export subsidies in 1986 and 1987 (column 5). Government budget subsidies to agriculture have exceeded tax revenues collected in every year since 1975. From 1979 to 1985, net subsidies to producers ranged from Rs 1.1 to 2.3 billion (1,000 million) per year. With the aforementioned drop in export tax revenues in the mid-1980s, net subsidies to producers averaged Rs 5.9 billion in 1986 and 1987.

These estimates of net subsidies to agricultural producers neglect most of the effects of government trade, exchange rate, and price policies, however. These policies have major effects on agricultural prices and production, as shown in the simulation results. Much of the resources that flow into or out of agriculture do not accrue to the government and so do not appear in calculations of government budget subsidies or taxes. Instead, these implicit transfers of resources accrue to consumers of agricultural products and to the nonagricultural sectors of the economy.

Both Qureshi (1988) and Nabi, Hamid, and Nasim (1987) estimate the size of price transfers based on calculations for five major crops: wheat, basmati rice, ordinary rice, sugarcane, and cotton. But the Qureshi estimates do not include any exchange rate adjustments. Thus in order to compare the estimates, the transfers shown in Tables 19, 20, and 21 are measures of the direct effects (with no exchange rate adjustments) for the five major crops only. From 1973 to 1983, the direct effect of output price intervention was a tax on agricultural producers of Rs 10-31 billion (Table 19, column 6). The direct effect of output price intervention in 1986 and 1987 is a subsidy to producers of Rs 1.7 billion in 1986 and Rs 1.3 billion in 1987. As discussed earlier, sharp declines in world prices of wheat, cotton, and rice in the mid-1980s caused border prices to fall relative to domestic prices.

Table 22 presents the various estimates of the transfers resulting from price policy intervention. The estimates by Qureshi are significantly lower than either the estimates

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[31] See Qureshi 1988.

## Table 22—Output price intervention effects based on three estimations, 1973-87

| Year/ Period | Direct Effects: Estimation for 5 Commodities[a] | Qureshi | Nabi, Hamid, and Nasim | Estimation for 12 Commodities[b] | Total Effects: Estimation for 5 Commodities[a] | Estimation for 12 Commodities[b] |
|---|---|---|---|---|---|---|
| | | | (Rs million) | | | |
| 1973 | -12,158 | -847 | -10,162 | -12,028 | -32,321 | -37,556 |
| 1974 | -30,609 | -6,873 | -34,849 | -31,279 | -53,817 | -59,750 |
| 1975 | -28,652 | -6,450 | -47,538 | -25,171 | -41,406 | -42,384 |
| 1976 | -19,833 | -4,665 | -32,451 | -12,293 | -36,649 | -35,980 |
| 1977 | -10,741 | -2,105 | -25,343 | 4,871 | -26,580 | -15,670 |
| 1978 | -10,560 | -8,561 | -25,953 | 6,803 | -24,691 | -10,978 |
| 1979 | -14,981 | -118 | -31,982 | -1,302 | -28,028 | -17,686 |
| 1980 | -27,719 | -1,479 | -39,198 | -13,667 | -43,613 | -32,257 |
| 1981 | -24,316 | -7,105 | -49,307 | -11,282 | -40,021 | -31,348 |
| 1982 | -10,352 | -1,867 | -45,824 | 7,354 | -23,458 | -11,152 |
| 1983 | -11,679 | -5,165 | -39,349 | 11,441 | -25,733 | -7,259 |
| 1984 | -7,104 | -5,551 | . . . | 18,151 | -21,842 | -3,330 |
| 1985 | -5,190 | -2,625 | . . . | 27,398 | -17,150 | 9,717 |
| 1986 | 1,673 | 4,585 | . . . | 36,041 | -12,704 | 13,875 |
| 1987 | 1,328 | 900 | . . . | 38,385 | -11,204 | 19,947 |
| Average | | | | | | |
| 1973-77 | -20,399 | -4,188 | -30,069 | -15,180 | -38,154 | -38,268 |
| 1978-82 | -17,586 | -3,826 | -38,453 | -2,419 | -31,962 | -20,684 |
| 1983-87 | -4,195 | -1,571 | -39,349 | 26,283 | -17,726 | 6,590 |
| 1973-87 | -14,060 | -3,195 | -34,723 | 2,895 | -29,281 | -17,454 |

Sources: The estimations for 5 and 12 commodities are based on model simulations prepared for this report. The Qureshi estimates are from Sarfraz Khan Qureshi, "Prices, Taxes and Subsidies: A Further Analysis of Issues Affecting Agricultural Sector of Pakistan," Pakistan Institute of Development Economics, Islamabad, 1988 (mimeo). The Nabi, Hamid, and Nasim estimations are from Ijaz Nabi, Naved Hamid, and Anjum Nasim, "A Comparative Study of the Political Economy of Agricultural Pricing Policies: The Case of Pakistan," revised, a report prepared for the World Bank, Washington, D.C. (mimeo).

[a] The 5 commodities are wheat, basmati rice, ordinary rice, sugarcane, and cotton.

[b] The 12 commodities are wheat, basmati rice, ordinary rice, sugarcane, cotton, maize, pulses, millet and sorghum, vegetable oil, fruit, milk, and meat.

presented in this report or those from Nabi, Hamid, and Nasim, for two major reasons. First, Qureshi calculates the price policy effect only for the amount of the crop that is marketed. This measures the transfers to agricultural producers net of their benefits or costs as consumers of agricultural products. Second, the three studies make different assumptions in calculating border prices. For example, for wheat—the most important crop in terms of value—both Qureshi and Nabi, Hamid, and Nasim use the average import price of wheat to calculate border prices rather than export prices in the world market.[32]

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[32] Qureshi (1988) estimates the border price of wheat in 1987 as Rs 3,132 per ton (import unit value) and marketing costs between farmgate and the wholesale market in Karachi at Rs 265 per ton. The difference between border prices and domestic prices is Rs 867 per ton. This study estimates the difference between border prices and domestic prices for wheat in 1987 as Rs 308 per ton, using a total marketing cost between farmgate and the import price of Rs 159 per ton, a figure 50 percent smaller than that of Qureshi. Multiplying the difference in prices by the estimate of marketed wheat (8,528,000 tons), the Qureshi estimate for the price policy effect for wheat is Rs 7.3 billion using total production of wheat and the alternative price differential gives Rs 4.3 billion.

## Table 23—Net transfers to agriculture from direct and indirect price and nonprice-related transfers for five commodities, based on model simulations, 1973-87

| Year/ Period | Total Direct Taxes (1) | Total Open Subsidies (2) | Total Concealed Subsidies (3) | Subtotal for Net Subsidies to Producers (1)+(2)+(3) (4) | Total Indirect Taxes (5) | Total Net Subsidies to Producers (4)+(5) (6) | Transfers Due to Output Price Interventions (Direct and Indirect) (7) | Subtotal for Price Intervention Effects (4)+(7) (8) | Public Investment in Research and Extension (9) | Total Price and Nonprice-Related Transfers (8)+(9) (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (Rs million) | | | | |
| 1973 | -167 | 441 | 40 | 314 | -712 | -398 | -32,321 | -32,007 | 1,598 | -30,409 |
| 1974 | -201 | 203 | 21 | 23 | -704 | -681 | -53,817 | -53,794 | 2,380 | -51,414 |
| 1975 | -232 | 454 | 339 | 561 | -692 | -131 | -41,406 | -40,845 | 3,127 | -37,718 |
| 1976 | -266 | 897 | 374 | 1,005 | -826 | 179 | -36,649 | -35,644 | 3,501 | -32,143 |
| 1977 | -136 | 920 | 394 | 1,178 | -372 | 806 | -26,580 | -25,402 | 4,433 | -20,969 |
| 1978 | -125 | 1,009 | 364 | 1,248 | -471 | 777 | -24,691 | -23,443 | 3,471 | -19,972 |
| 1979 | -291 | 1,991 | 389 | 2,089 | -247 | 1,842 | -28,028 | -25,939 | 4,391 | -21,549 |
| 1980 | -175 | 2,723 | 344 | 2,892 | -1,015 | 1,877 | -43,613 | -40,721 | 4,298 | -36,423 |
| 1981 | -227 | 2,479 | 680 | 2,932 | -1,860 | 1,072 | -40,021 | -37,089 | 5,934 | -31,155 |
| 1982 | -287 | 1,826 | 936 | 2,475 | -348 | 2,127 | -23,458 | -20,983 | 6,332 | -14,651 |
| 1983 | -427 | 1,980 | 932 | 2,485 | -1,410 | 1,075 | -25,733 | -23,248 | 7,869 | -15,380 |
| 1984 | -465 | 1,466 | 1,455 | 2,456 | -1,036 | 1,420 | -21,842 | -19,386 | 9,000 | -10,386 |
| 1985 | -505 | 1,501 | 2,220 | 3,216 | -878 | 2,338 | -17,150 | -13,934 | 10,000 | -3,934 |
| 1986 | -460 | 2,424 | 2,366 | 4,331 | 1,002 | 5,333 | -12,704 | -8,373 | 10,100 | 1,727 |
| 1987 | -365 | 2,044 | 3,250 | 4,929 | 1,526 | 6,455 | -11,204 | -6,276 | 10,300 | 4,024 |
| Average | | | | | | | | | | |
| 1973-77 | -201 | 583 | 234 | 616 | -661 | -45 | -38,154 | -37,538 | 3,008 | -34,530 |
| 1978-82 | -221 | 2,006 | 543 | 2,327 | -788 | 1,539 | -31,962 | -29,635 | 4,885 | -24,750 |
| 1983-87 | -445 | 1,883 | 2,045 | 3,483 | -159 | 3,324 | -17,726 | -14,243 | 9,454 | -4,790 |
| 1973-87 | -289 | 1,491 | 940 | 2,142 | -536 | 1,606 | -29,281 | -27,139 | 5,782 | -21,357 |

Source: Authors' calculations based on Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: The 5 commodities included are wheat, basmati rice, ordinary rice, sugarcane, and cotton. For years 1977, 1978, 1980, 1984, and 1985 in column (2), figures were changed from Qureshi's paper to reflect the data from the *Economic Survey*. In column (8), indirect taxes (export duties and corporation profits on rice and cotton and cesses on sugarcane and cotton) were not separately added in because they are already reflected in the transfers from outprice interventions. Open subsidies (2) include subsidies on fertilizer, tubewells, plant protection and seeds. Concealed subsidies (3) include subsidies on irrigations (does not include recovery on capital investment), agricultural credit, and electricity. Figures in columns (1), (2), (3), (5), and (9) are based on official actual figures, not estimates. Transfers due to output price interventions (7) are computed at the actual level of production.

Estimates of the total direct and indirect effects of price policy for the five crops are also presented in Tables 22 and 23. Transfers out of agriculture are substantial, averaging about Rs 35 billion per year from 1972 to 1982 and about Rs 12 billion per year in 1986 and 1987. When all 12 agricultural subsectors modeled are included, the direct and total effects of price policy (including an exchange rate adjustment) result in approximately the same level of transfers up to the mid-1970s (Table 23). In the late 1970s and early 1980s the estimated size of subsidies rose substantially due to the differential between historical world and domestic milk prices, so that by 1985 the total transfer was positive (that is, agriculture was subsidized). Estimates of both direct and total effects of price policy from Nabi, Hamid, and Nasim (1987) are shown in Table 24.

Nabi, Hamid, and Nasim (1987) estimate transfers into agriculture in the form of public investment and research and extension expenditures (see Tables 19 and 22, column 9). Although the full benefit of these investments does not accrue to farmers in the year the investments are made, the investment series represents a measure of the transfers to the agricultural sector in a given year. From the farmers' point of view, however, one rupee transferred through public investment is not necessarily equivalent to one rupee transferred from price interventions. Public investment in infrastructure and expenditures on research and extension increased from Rs 1.6 billion in 1973 to Rs 7.9 billion in 1983, equal to roughly 20 percent of the taxes due to output price intervention for the five major crops in Pakistan (Table 19). However, the actual transfer to farmers arising from public investment in infrastructure and expenditures on research and extension are likely to be much greater than the fiscal value of the government investment, especially for research and extension of improved agricultural technology.

Another indication of the size of the transfers is shown in Table 25. In the 1973-77 period, total net transfers out of agriculture averaged 39 percent of GDP. Total net transfers were still 12 percent of GDP in the 1978-82 period, but fell to 2 percent of GDP in 1983-87 because of low world prices of cotton, rice, wheat, and milk. As a percentage of agricultural GDP, the corresponding figures for net transfers are of course much higher. These were 115 percent for 1973- 77, 41 percent for 1978-82, and 7 percent for 1983-87, for the five major crops.

### Table 24—Estimates of transfers into and out of agriculture, based on Nabi, Hamid, and Nasim (1988), 1960-87

| Period | Land Revenue and *Usher*[a] | Public Investment in Research and Extension | Total Nonprice Transfers | Price-Related Transfers Direct | Price-Related Transfers Total | Total of Price and Nonprice Transfers Direct | Total of Price and Nonprice Transfers Total |
|---|---|---|---|---|---|---|---|
| (average) | | | (Rs million) | | | | |
| 1960-65 | −120 | 573 | 453 | 848 | −1,455 | 1,301 | −1,002 |
| 1966-70 | −105 | 1,284 | 1,179 | 985 | −4,172 | 2,164 | −2,993 |
| 1971-75 | −164 | 1,871 | 1,706 | −3,438 | −15,536 | −1,732 | −13,830 |
| 1976-80 | −277 | 4,609 | 4,332 | −5,205 | −26,221 | −873 | −21,889 |
| 1981-85 | −445 | 7,833 | 7,387 | −12,092 | −48,205 | −4,705 | −40,817 |
| 1986-87 | −381 | 10,257 | 9,876 | −6,192 | −32,593 | 3,684 | −22,717 |

Source: Based on Ijaz Nabi, Naved Hamid, and Anjum Nasim, "A Comparative Study of the Political Economy of Agricultural Pricing Policies: The Case of Pakistan," report prepared for the World Bank, Washington, D.C., 1987 (mimeo).

Note: A minus sign indicates a transfer out of agriculture.

[a] The *usher* [illegible] a levy collected from Muslim landowners and leaseholders.

## Table 25—Direct and total price and nonprice-related transfers as a percentage of GDP, for five commodities, 1973-87

| Year/Period | Direct Effects: Net Subsidies to Producers (1) | Transfers Due to Output Price Intervention (Direct) (2) | Public Investment and Research and Extension (3) | Total Price and Nonprice-Related Transfers (1)+(2)+(3) (4) | Total Effects: Transfers Due to Output Price Intervention (Direct and Indirect) (5) | Total Price and Nonprice-Related Effects (1)+(5)+(3) (6) |
|---|---|---|---|---|---|---|
| | | | | (percent of GDP) | | |
| 1973 | 0.46 | -18.01 | 2.37 | -15.18 | -52.63 | -49.80 |
| 1974 | 0.03 | -34.74 | 2.70 | -32.01 | -65.88 | -63.15 |
| 1975 | 0.50 | -25.77 | 2.81 | -22.45 | -39.98 | -36.67 |
| 1976 | 0.77 | -15.21 | 2.69 | -11.76 | -30.61 | -27.15 |
| 1977 | 0.79 | -7.17 | 2.96 | -3.43 | -19.55 | -15.80 |
| 1978 | 0.71 | -5.99 | 1.97 | -3.31 | -15.45 | -12.77 |
| 1979 | 1.07 | -7.69 | 2.25 | -4.36 | -15.76 | -12.44 |
| 1980 | 1.24 | -11.84 | 1.84 | -8.77 | -20.74 | -17.67 |
| 1981 | 1.06 | -8.77 | 2.14 | -5.57 | -16.20 | -13.00 |
| 1982 | 0.77 | -3.22 | 1.97 | -0.48 | -8.09 | -5.36 |
| 1983 | 0.68 | -3.21 | 2.16 | -0.36 | -7.85 | -5.00 |
| 1984 | 0.58 | -1.69 | 2.14 | 1.03 | -5.81 | -3.09 |
| 1985 | 0.67 | -1.08 | 2.07 | 1.66 | -3.94 | -1.20 |
| 1986 | 0.79 | 0.31 | 1.85 | 2.94 | -2.60 | 0.04 |
| 1987 | 0.81 | 0.22 | 1.69 | 2.72 | -2.05 | 0.45 |
| Average | | | | | | |
| 1973-77 | 0.51 | -20.18 | 2.71 | -16.97 | -41.73 | -38.51 |
| 1978-82 | 0.97 | -7.50 | 2.03 | -4.50 | -15.25 | -12.25 |
| 1983-87 | 0.71 | -1.09 | 1.98 | 1.60 | -4.45 | -1.76 |
| 1973-87 | 0.73 | -9.59 | 2.24 | -6.62 | -20.48 | -17.51 |

Source: Authors' calculations based on model simulations and Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).
Note: The 5 commodities included are wheat, basmati rice, ordinary rice, sugarcane, and cotton.

## Suggestions for Further Modeling

The price policies simulated above are meant to provide a measure of the effects of historical government policies compared with a free-trade policy framework. As such, the simulated counterfactual policies are not intended as realistic policy alternatives in themselves. Some of the problems that would arise under a free-trade regime have already been mentioned and a full discussion is contained in the concluding chapter. The modeling technique used could itself be improved to better simulate the effects of exchange rate, trade, and agricultural price policies in Pakistan.

As discussed earlier, including agricultural investment and capital stock in the model would better capture long-term effects of changes in relative price incentives between agriculture and nonagriculture. An explicit model of the agricultural labor market, including rural-urban migration could also be specified.

One important result of the simulations was the potentially large effect of free trade in milk on milk output, prices, and overall agricultural income. Because milk is a large subsector in agriculture, large imports of milk at lower world prices in conjunction with decreases in milk production would, according to the simulation, have a large effect on agricultural incomes and measures of transfers into and out of agriculture. In the model, imported powdered milk and fresh milk are perfect substitutes (albeit with a quality factor adjustment in calculating equivalent prices of the two commodities). A more realistic demand specification would also include disaggregation of milk demand by rural and urban groups. Domestic supply of milk might also be modeled using the capital stock of cows and buffalo.

The behavior of the sugar industry in the model simulations is perhaps unrealistic in that the capacity for sugar refining is assumed (implicitly) to remain in operation despite violent swings in domestic sugarcane production. Avoiding large variations in domestic sugarcane production and enabling sugar refineries to be financially viable are strong arguments in favor of some form of price stabilization in sugar. (The level at which sugar prices are stabilized is a different, very important issue.)

Finally, a better model of both the meat and fruit subsectors could be obtained by incorporating some form of agricultural investment and capital. Modeling potential exports of these commodities under free trade with exchange-rate adjustments is also difficult because higher prices alone may not be sufficient to induce a large increase in exports without significant investments in infrastructure and the gradual development of trading contacts to establish new markets.

# 9

# CONCLUSIONS

Indirect effects of exchange rate policies have been a major factor in determining the overall effects of government policy interventions on agricultural price incentives. Trade policies designed to protect industrial sectors led to an appreciation of the real exchange rate of about 22 percent in the 1960s and about 10 percent in the mid-1970s. Despite the adoption of a managed float nominal exchange rate policy, quantitative restrictions on imports in 1987 resulted in a high implicit import tariff of 47 percent and an appreciation of the real exchange rate estimated at 19 percent.

Appreciation of the real exchange rate has reduced and sometimes reversed the protection provided by agricultural trade policies for some commodities. The overvaluation of the rupee in the 1960s outweighed the protection provided by direct trade policies for wheat, ordinary rice, and cotton, and increased the taxation of basmati rice. Direct effects of trade policies were dominant for wheat, basmati rice, and ordinary rice in the 1970s and early 1980s because the exchange rate effect (the distortion caused by the appreciation of the real exchange rate) was smaller than in the 1960s. For cotton, trade policies had only a small direct effect on domestic prices, but domestic prices remained significantly lower than equilibrium free-trade prices because of the indirect effects of exchange rate appreciation and overall trade policy.

For both wheat and basmati rice, the combined effects of Pakistan's trade and exchange rate policies changed little over almost three decades, because domestic prices were consistently kept below the free-trade equilibrium border prices. A similar story could have been told for seed cotton and ordinary rice up until the early 1980s. However, large declines in world prices of cotton and rice in recent years have resulted in significant reductions in implicit taxation because domestic prices of these commodities have not been allowed to fall as precipitously. Instead, government policies have helped stabilize domestic prices at the cost of losses in tax revenues. The drop in measured levels of taxation of these products may be temporary, however, if world prices rise to previous levels and domestic prices remain near the 1987 levels.

Thus, the five major agricultural products (wheat, basmati rice, ordinary rice, cotton, and sugarcane) were consistently taxed from the 1960s to the early 1980s. As a result, production of these crops suffered. Due to the combined effect of trade and exchange rate policies and agricultural price policies, wheat production was 24 percent lower and basmati rice 52 percent lower in the 1983-87 period than they would have been with no government intervention. In the absence of direct and indirect price interventions, farm incomes from these five major crops would have been 40 percent higher during that period.

Government intervention in agricultural markets also had positive effects, however. Domestic prices of all major agricultural commodities except vegetable oil and fertilizer were less variable than world prices evaluated at the free-trade equilibrium exchange rate. The large dairy sector also greatly benefited from protection from milk imports. In the simulation of free trade with equilibrium exchange rates, milk production fell by 25 percent in the 1978-87 period. As a result, despite large increases in farmers' gross income from major crops, total agricultural gross income increased by only 4 percent.

Transfers out of agriculture due to direct and indirect price policies averaged, for the five major crops, Rs 25 billion per year in the 1978-87 period, about 36 percent of agricultural value added. This implicit tax on agriculture was about nine times the estimated level of net subsidies to producers (both budgetary and off-budget) and more than three times public expenditures on research, extension, and infrastructure for agriculture (about Rs 7 billion per year in the 1978-87 period). The Rs 25 billion mostly went to other sectors of the economy and to consumers—not to the government as revenue—because it resulted from quantitative restrictions on imports and not from direct tariffs. Thus, the net effect of price and nonprice-related income transfers is estimated to have been a transfer out of agriculture of approximately 25 percent of agricultural GDP during 1978-87.

When other agricultural commodities (particularly milk, which benefited from an implicit subsidy on production) are included, transfers out of agriculture are reduced to Rs 14 billion in the same period (from 1985 to 1987 transfers were positive)—about 16 percent agricultural value added. The declining trend in the total transfers out of agriculture is mainly due to a decline in world prices of a number of agricultural commodities. In the longer run, it is likely that, without a change in exchange rate or trade policies, total transfers out of agriculture will again be positive as world prices rise.

Without government subsidies for consumers, higher prices for major food crops would mean higher consumer prices for major food crops as well (the removal of the implicit subsidy for consumers). In simulating free trade with equilibrium exchange rates and net trade increases, consumption of food crops declined. Wheat became an export good, with wheat exports rising to 3.7 million tons in the simulation of the 1978-87 period. (Historically, Pakistan imported an average of 858,000 tons in this period.)

Although not modeled here, the foregone agricultural production resulting from government trade and exchange rate and agricultural price policies implies fewer rural employment opportunities, lower labor incomes, and greater incentives for rural-to-urban migration. Incentives for investment in agricultural capital would be reduced as well.

Some of the other sectors of the economy benefited from these policies. In particular, import-competing industries enjoyed protection behind the high implicit import tariffs, and all consumers faced lower and more stable prices for food products but higher prices for nonfood goods and services.

Given the inherent inability of most agricultural supply models, including this one, to capture fully the interdependence between sectors (that is, the effects on investment behavior, labor and capital flows, and others), the output response predicted here should be considered as a very preliminary result. The effects of these intersectoral resource flows are likely to be of lesser importance, however, for the simulations of the direct effects than of the total effects.

It should be emphasized that these quantitative results are meant mainly as an aid to understanding some of the major linkages between macroeconomic policies and agriculture; they provide only rough estimates of the magnitudes of policy effects. The model used does not capture longer-run effects of price policies on agricultural investment and capital, considerations likely to be important for the livestock and dairy sectors in particular. Supply and demand parameters (taken from Hamid et al. 1987) are known only approximately and fail to explicitly capture differences in rural and urban consumption patterns. Moreover, the model simulations assume no change in public investment in agriculture and rural infrastructure compared with historical levels. This is not meant to imply that these investments did not play a significant role in Pakistan's agricultural development. The simulations merely reflect the purpose of the study: to assess the effects on agriculture of government macroeconomic and sectoral price interventions, holding other factors (including public investment) constant.

Finally, the scenarios modeling free trade with and without real exchange rate adjustments are not meant as policy recommendations. Rather, the simulations enable the indirect effects of macroeconomic policies to be highlighted and analyzed. On this issue, two other considerations should be noted: (1) the indirect price interventions as such do not yield revenue to the government (at least not from the agricultural sector, although industrial protection could yield revenues if tariffs apply, whereas in Pakistan quantitative restrictions predominate); (2) the direct price interventions on exports yield revenues, and this could be a factor to consider in the transition. Placing tariffs on all importables would certainly more than compensate for the reduction in fiscal revenues from elimination of export taxes on agricultural exportables.

There may be some scope for increasing the direct taxation of agriculture, particularly if the indirect taxation of agriculture arising through trade and exchange rate policies is reduced (for example, by reducing import restrictions in the nonagricultural sector). In theory, it would be possible to levy direct taxes on agriculture in conjunction with changes in trade and exchange rate policies that reduce the indirect taxation of agriculture so that agricultural incomes are unchanged. In practice, a direct taxation of agriculture is made difficult by problems in measuring agricultural incomes, valuation of land, and tax avoidance. The issues involved in a complete analysis of fiscal policy are complex; they involve comparisons of taxes and expenditures across sectors of the economy—issues that are beyond the scope of this study.

This paper has shown that the indirect effects of trade and exchange rate policies on agricultural producer prices are large and have persisted for more than two decades for several major commodities. Indirect effects taxed producers and subsidized consumers of most food crops and cotton. Milk was the only major commodity for which the indirect effects (appreciation of the real exchange rate) did not outweigh the high levels of direct protection in the last decade. For most of the period, the net effect of the prevailing policies was lower overall agricultural growth. These indirect effects, therefore, are too large to be ignored and should be taken into account in the analysis of agricultural pricing policy and taxation in Pakistan, as well as in the design of trade policy for the nonagricultural sector.

# APPENDIX 1: SUPPLEMENTARY TABLES

**Table 26—Tariffs and effective exchange rates, 1960-87**

| Year | $1 + t_m$ (1) | $1 - t_x$ (2) | Equivalent Tariff (3) | E (4) | $E_x$ (5) | $E_m$ (6) |
|---|---|---|---|---|---|---|
| 1960 | 2.34 | 1.65 | 1.42 | 4.78 | 7.89 | 11.19 |
| 1961 | 2.34 | 1.69 | 1.38 | 4.79 | 8.10 | 11.18 |
| 1962 | 2.36 | 1.62 | 1.45 | 4.77 | 7.74 | 11.25 |
| 1963 | 2.45 | 1.56 | 1.57 | 4.79 | 7.48 | 11.74 |
| 1964 | 2.52 | 1.62 | 1.55 | 4.79 | 7.77 | 12.06 |
| 1965 | 2.85 | 1.77 | 1.61 | 4.80 | 8.49 | 13.70 |
| 1966 | 2.73 | 1.64 | 1.67 | 4.79 | 7.84 | 13.07 |
| 1967 | 2.86 | 1.59 | 1.79 | 4.80 | 7.65 | 13.73 |
| 1968 | 3.01 | 1.66 | 1.81 | 4.79 | 7.95 | 14.40 |
| 1969 | 3.14 | 1.77 | 1.78 | 4.80 | 8.50 | 15.09 |
| 1970 | 3.02 | 1.73 | 1.74 | 4.79 | 8.30 | 14.45 |
| 1971 | 3.22 | 2.00 | 1.62 | 4.78 | 9.54 | 15.42 |
| 1972 | 2.65 | 1.78 | 1.48 | 5.56 | 9.92 | 14.73 |
| 1973 | 1.53 | 1.08 | 1.41 | 10.56 | 11.45 | 16.11 |
| 1974 | 1.33 | 0.90 | 1.47 | 9.90 | 8.93 | 13.15 |
| 1975 | 1.24 | 0.99 | 1.25 | 9.90 | 9.77 | 12.24 |
| 1976 | 1.44 | 1.19 | 1.21 | 9.90 | 11.75 | 14.28 |
| 1977 | 1.53 | 1.18 | 1.30 | 9.90 | 11.68 | 15.13 |
| 1978 | 1.46 | 1.17 | 1.24 | 9.90 | 11.58 | 14.41 |
| 1979 | 1.51 | 1.01 | 1.49 | 9.90 | 10.00 | 14.91 |
| 1980 | 1.55 | 0.96 | 1.62 | 9.90 | 9.49 | 15.35 |
| 1981 | 1.55 | 1.03 | 1.51 | 9.90 | 10.17 | 15.33 |
| 1982 | 1.44 | 1.04 | 1.38 | 10.55 | 11.01 | 15.17 |
| 1983 | 1.42 | 1.01 | 1.41 | 12.70 | 12.81 | 18.04 |
| 1984 | 1.47 | 1.05 | 1.40 | 13.48 | 14.21 | 19.85 |
| 1985 | 1.46 | 0.95 | 1.53 | 15.16 | 14.46 | 22.07 |
| 1986 | 1.52 | 1.00 | 1.51 | 16.13 | 16.18 | 24.47 |
| 1987 | 1.47 | 0.95 | 1.54 | 17.17 | 16.35 | 25.23 |

Source: Authors's calculations based on Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: In column (1), $t_m$ is the implicit tariff on imports. Weights for 1972-87 are as follows (1960-71 weights are in parentheses): fuel, 0.30 (0.04); fertilizer, 0.05 (0.03); wheat, 0.05 (0.10); and vegetable ghee, 0.05 (0.03).

In column (2), $t_x$ is the implicit tax on exports.

Weights for 1972-87 are as follows (1960-71 weights are in parentheses): raw cotton, 0.31 (0.44); cotton yarn, 0.12 (0.18); cotton textiles, 0.14 (0.19); basmati rice, 0.33 (0.19); and petroleum, 0.10 (0.00). See Chapter 4, equation (4).

(3) The equivalent tariff = $(1 + t_m) / (1 - t_x)$.

(4) E is the effective exchange rate.

(5) $E_x$ = effective exchange rate for exports = (4) • (2).

(6) $E_m$ = Effective exchange rate for imports = (4) • (1).

## Table 27—Equivalent tariff calculations, 1963/64

| Item | Exports | Effective Exchange Rate |
|---|---|---|
| | (US$ million) | |
| Raw cotton | 71.4 | 4.45 |
| Hides and skins | 10.7 | 4.76 |
| Raw wool | 15.7 | 4.76 |
| Cotton yarn, goods | 39.8 | 6.31 |
| Rice | 22.2 | 6.21 |
| Footwear | 2.5 | 7.66 |
| Leather goods | 8.0 | 10.34 |
| Sport goods | 3.9 | 10.31 |
| Carpets | 6.2 | 8.05 |
| Wheat | 0.2 | 4.76 |
| Other | 55.3 | 7.66 |
| Raw jute | 158.1 | 4.28 |
| Tea | 0.0 | ... |
| Jute goods | 67.9 | 5.71 |
| Fish | 21.0 | 4.76 |
| Total | 482.9 | ... |
| Average export tax | ... | –13.69 |
| Total West Pakistan | 235.9 | ... |
| Average export tax (West Pakistan) | ... | –29.04 |

| Item | Imports | Nominal Rate of Protection |
|---|---|---|
| | (US$ million) | |
| Chemicals | 57.4 | 81 |
| Electric goods | 27.0 | 308 |
| Machinery | 194.2 | 60 |
| Paper products | 8.1 | 94 |
| Rubber manufacturing | 12.4 | 153 |
| Transport equipment | 100.5 | 249 |
| Art silk, yarn | 7.3 | 350 |
| Cotton manufactures | 2.8 | 225 |
| Iron, steel manufactures | 125.4 | 95 |
| Nonferrous metal | 16.8 | 66 |
| Oil (mineral) | 51.1 | 107 |
| Vegetable oil | 26.2 | 106 |
| Grains, pulses, flour | 120.4 | 85 |
| Other imports | 178.4 | 85 |
| Total | 928.0 | ... |
| Average | ... | 110.08 |

Sources: For the effective exchange rate, A. R. Kemal and Paul A. Popiel, "Effective Exchange Rates of Exported or Exportable Products in Pakistan," Pakistan Institute of Development Economics, Islamabad, and the World Bank, Washington, D.C., 1980, Appendix Table 1, except for cotton yarn goods, jute goods, and others (assumed manufactures). The effective exchange rates for these goods are from S. R. Lewis, *Pakistan: Industrialization and Trade Policies* (London: Oxford University Press, 1970), Table 4.16. Export and import tables are from Lewis, *Pakistan: Industrialization and Trade Policies*, Tables A.16 and A.17.

Notes: Footwear is assumed to equal 7.66; fish, wheat, hides, and wool are assumed to equal 4.76.

## Table 28—Equilibrium exchange rates using a modified elasticities approach, 1960-87

| Year | Trade Deficit | $1 + t_m$ | $1 - t_x$ | E | $Q1_{tx}$ | $E1^*_{tx}$ | $E2^*_{tx}$ |
|---|---|---|---|---|---|---|---|
| | (Rs million) | (Rs/US$) | (Rs/US$) | (Rs/US$) | (Rs million) | (Rs/US$) | (Rs/US$) |
| 1960 | 1,066 | 2.34 | 1.65 | 4.78 | 1,065 | 11.75 | 9.82 |
| 1961 | 1,659 | 2.34 | 1.69 | 4.79 | 1,207 | 12.86 | 10.10 |
| 1962 | 1,720 | 2.36 | 1.62 | 4.77 | 1,402 | 12.56 | 9.90 |
| 1963 | 1,851 | 2.45 | 1.56 | 4.79 | 2,034 | 11.89 | 9.78 |
| 1964 | 1,942 | 2.52 | 1.62 | 4.79 | 2,130 | 12.28 | 10.12 |
| 1965 | 2,587 | 2.85 | 1.77 | 4.80 | 2,783 | 13.91 | 11.30 |
| 1966 | 1,726 | 2.73 | 1.64 | 4.79 | 2,300 | 12.44 | 10.47 |
| 1967 | 2,377 | 2.86 | 1.59 | 4.80 | 3,220 | 12.66 | 10.52 |
| 1968 | 1,705 | 3.01 | 1.66 | 4.79 | 2,984 | 12.46 | 10.83 |
| 1969 | 1,377 | 3.14 | 1.77 | 4.80 | 2,659 | 12.92 | 11.42 |
| 1970 | 1,673 | 3.02 | 1.73 | 4.79 | 2,806 | 12.83 | 11.13 |
| 1971 | 1,686 | 3.22 | 2.00 | 4.78 | 2,729 | 14.20 | 12.43 |
| 1972 | 25 | 2.65 | 1.78 | 5.56 | 5,873 | 15.49 | 15.47 |
| 1973 | −616 | 1.53 | 1.08 | 10.56 | 6,486 | 12.96 | 13.21 |
| 1974 | 2,701 | 1.33 | 0.90 | 9.90 | 5,491 | 12.05 | 11.34 |
| 1975 | 9,492 | 1.24 | 0.99 | 9.90 | 7,985 | 13.15 | 11.38 |
| 1976 | 6,220 | 1.44 | 1.19 | 9.90 | 14,781 | 13.67 | 12.55 |
| 1977 | 6,238 | 1.53 | 1.18 | 9.90 | 18,502 | 13.80 | 12.82 |
| 1978 | 2,696 | 1.46 | 1.17 | 9.90 | 21,177 | 12.83 | 12.50 |
| 1979 | 4,930 | 1.51 | 1.01 | 9.90 | 24,891 | 12.73 | 12.26 |
| 1980 | 5,235 | 1.55 | 0.96 | 9.90 | 31,567 | 12.59 | 12.21 |
| 1981 | 1,572 | 1.55 | 1.03 | 9.90 | 39,513 | 12.46 | 12.36 |
| 1982 | 7,863 | 1.44 | 1.04 | 10.55 | 38,335 | 13.41 | 12.92 |
| 1983 | −5,686 | 1.42 | 1.01 | 12.70 | 41,046 | 14.84 | 15.18 |
| 1984 | −227 | 1.47 | 1.05 | 13.48 | 52,714 | 16.55 | 16.56 |
| 1985 | 13,488 | 1.46 | 0.95 | 15.16 | 52,557 | 19.07 | 18.27 |
| 1986 | −5 | 1.52 | 1.00 | 16.13 | 62,226 | 19.81 | 19.81 |
| 1987 | −8,126 | 1.47 | 0.95 | 17.17 | 52,432 | 19.90 | 20.40 |

Source: Author's calculations based on Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: $t_m$ = the implicit tariff on imports and $t_x$ = the implicit tax on exports.

E = the actual nominal exchange rate.

$Q1_{tx}$ = current account imbalance due to trade taxes and quotas

$= (T / 1 + T) \cdot Q_D \cdot n_D, [1 + T = (1 + t_M) / (1 - t_X)],$ 1960-72

$= [t_m / (1 + t_m)] \cdot Q_D \cdot n_D - [t_x / (1 - t_x)] \cdot (Q_S + \text{Remit}) \cdot e_S .$ 1973-87.

$$E1^*_{tx} = E \cdot (1 - t_x) \cdot \left\{ \frac{(\text{Trade Deficit} + Q1_{tx})}{[Q_D \cdot n_D + (Q_S + \text{Remit}) \cdot e_S]} + 1 \right\} \qquad 1960\text{-}72$$

$$= E \cdot \left\{ \frac{(\text{Trade Deficit} + Q1_{tx})}{[Q_D \cdot n_D + (Q_S + \text{Remit}) \cdot e_S]} + 1 \right\} \qquad 1973\text{-}87.$$

$E2^*_{tx} = E \cdot ($ [illegible] $1_{tx}/[Q_D \cdot n_D + (Q_S) + \text{Remit}] \cdot e_S + 1\},$ 1960-72

$= E \cdot \{Q1_{tx} / [Q_D \cdot n_D + (Q_S + \text{Remit}) \cdot e_S] + 1\}.$ 1973-87.

In the equations above,

$Q_D$ = the demand for foreign exchange (the level of imports),
$n_D$ = the elasticity of supply of foreign exchange (the elasticity of demand for imports),
$Q_S$ = the supply of foreign exchange (the level of exports), and
$e_S$ = the elasticity of supply of foreign exchange (the elasticity of supply of exports).

## Table 29—Domestic supply (area and yield) elasticities

| Commodity | Elasticity of Area with Respect to Price | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wheat | Maize | Millet and Sorghum | Basmati Rice | Other Rice | Pulses | Sugar | Vegetable Oil | Fruit | Milk | Meat | Cotton |
| Area elasticity | | | | | | | | | | | | |
| Wheat | 0.090 | 0.002 | -0.000 | 0.003 | 0.009 | -0.003 | 0.007 | -0.002 | 0.001 | 0.012 | 0.005 | 0.009 |
| Maize | 0.034 | 0.250 | -0.050 | -0.012 | 0.003 | -0.004 | -0.042 | -0.018 | -0.001 | 0.018 | 0.011 | -0.024 |
| Millet and sorghum | 0.031 | -0.040 | 0.200 | -0.005 | 0.006 | -0.004 | -0.023 | -0.005 | -0.002 | 0.014 | 0.007 | -0.017 |
| Basmati | 0.090 | -0.015 | -0.013 | 0.600 | -0.159 | -0.024 | -0.094 | -0.005 | -0.002 | 0.010 | 0.003 | -0.056 |
| Other rice | 0.042 | -0.001 | -0.001 | -0.114 | 0.250 | -0.004 | -0.029 | -0.000 | -0.000 | 0.010 | 0.003 | -0.024 |
| Pulses | 0.017 | -0.001 | -0.003 | -0.009 | 0.004 | 0.250 | -0.029 | -0.037 | -0.000 | 0.010 | 0.003 | -0.030 |
| Sugar | 0.006 | -0.023 | -0.019 | -0.043 | -0.019 | -0.031 | 0.500 | -0.037 | -0.012 | 0.010 | 0.003 | -0.115 |
| Vegetable oil | -0.002 | -0.028 | -0.011 | -0.003 | 0.005 | -0.100 | -0.124 | 0.400 | -0.002 | 0.018 | 0.011 | 0.015 |
| Fruit | 0.003 | -0.002 | -0.003 | -0.002 | -0.000 | -0.002 | -0.029 | -0.002 | 0.100 | 0.004 | 0.001 | -0.016 |
| Milk | 0.028 | 0.006 | 0.001 | 0.004 | 0.006 | 0.001 | 0.010 | 0.005 | 0.001 | 0.200 | 0.047 | 0.013 |
| Meat | 0.028 | 0.006 | 0.001 | 0.004 | 0.006 | 0.001 | 0.010 | 0.005 | 0.001 | 0.054 | 0.200 | 0.013 |
| Cotton | 0.004 | -0.013 | -0.015 | -0.021 | -0.014 | -0.028 | -0.093 | 0.000 | -0.006 | 0.013 | 0.006 | 0.350 |
| Yield elasticity | | | | | | | | | | | | |
| Own price | 0.34 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.10 | 0.00 | 0.00 | 0.35 |
| Cross price | -0.04[a] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.04[b] |
| Adjusted parameter | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.85 | 0.60 | 0.60 | 0.35 |

Source: N. Hamid, Thomas C. Pinckney, Susanne Gnaegy, and Alberto Valdés, "The Wheat Economy of Pakistan: Setting and Prospects," International Food Policy Research Institute, Washington, D.C., 1987 (mimeo).

Note: Area elasticities shown in row i and column j represent the percentage change in area of commodtiy i for a 1 percent change in the price of commodity j.

[a] This is the cross-price elasticity of wheat with respect to cotton.

[b] This is the cross-price elasticity of cotton with respect to wheat.

## Table 30—Price and income elasticities of demand

| Commodity | Wheat | Maize | Millet and Sorghum | Basmati Rice | Other Rice | Pulses | Sugar | Vegetable Oil | Fruit | Milk | Meat | Cotton |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price elasticity | | | | | | | | | | | | |
| Wheat | -0.2500 | 0.0044 | 0.0054 | 0.0250 | 0.0180 | 0.0055 | 0.0066 | 0.0328 | 0.0044 | 0.0260 | -0.0034 | -0.0043 |
| Maize | 0.1403 | -0.3500 | 0.0797 | 0.0190 | 0.0140 | 0.0181 | 0.0066 | 0.0067 | 0.0086 | 0.0010 | 0.0014 | -0.0023 |
| Millet and sorghum | 0.2755 | 0.0844 | -0.3800 | 0.0305 | 0.0255 | 0.0386 | 0.0436 | 0.0428 | 0.0236 | 0.0997 | 0.0964 | 0.0225 |
| Basmati | 0.1474 | 0.0028 | 0.0028 | -0.7000 | 0.1195 | 0.0014 | -0.0206 | -0.0028 | 0.0114 | -0.0297 | -0.0464 | -0.0225 |
| Other rice | 0.1828 | 0.0046 | 0.0045 | 0.1305 | -0.4000 | 0.0109 | 0.0067 | 0.0116 | 0.0107 | 0.0245 | 0.0143 | 0.0011 |
| Pulse | 0.0450 | 0.0033 | 0.0033 | 0.0112 | 0.0056 | -0.3000 | 0.0050 | 0.0100 | 0.0100 | 0.0700 | 0.0700 | 0.0000 |
| Sugar | -0.0450 | -0.0018 | -0.0018 | -0.0051 | -0.0075 | -0.0134 | -0.4500 | 0.0315 | 0.0582 | 0.0020 | 0.0048 | -0.0196 |
| Vegetable oil | 0.0280 | -0.0018 | -0.0018 | 0.0003 | -0.0061 | -0.0109 | 0.0317 | -0.5700 | 0.0379 | 0.0102 | 0.0231 | -0.0200 |
| Fruit | -0.0553 | -0.0012 | -0.0011 | 0.0077 | -0.0039 | -0.0069 | 0.1363 | 0.0844 | -0.7600 | 0.0304 | -0.0559 | -0.0250 |
| Milk | -0.0168 | -0.0017 | -0.0017 | 0.0001 | -0.0046 | 0.0022 | 0.0078 | 0.0113 | 0.0107 | -0.5800 | 0.1830 | -0.0149 |
| Meat | -0.1163 | -0.0040 | -0.0039 | -0.0098 | -0.0134 | -0.0110 | -0.0160 | -0.0080 | -0.0127 | 0.1235 | -0.8000 | -0.0315 |
| Cotton | -0.0754 | -0.0025 | -0.0025 | -0.0085 | -0.0085 | -0.0151 | -0.0272 | -0.0265 | -0.0110 | -0.0726 | -0.0700 | -0.5900 |
| Income elasticity | 0.19 | 0.10 | -1.00 | 1.06 | -0.05 | 0.00 | 0.87 | 0.89 | 1.11 | 0.66 | 0.81 | 1.40 |

Source: N. Hamid, Thomas C. Pinckney, Susanne Gnaegy, and Alberto Valdés, "The Wheat Economy of Pakistan: Setting and Prospects," International Food Policy Research Institute, Washington, D.C., 1987 (mimeo).

Note: Demand elasticities shown in row i and column j represent the percentage change in quantity demanded of commodity i for a 1 percent change in the price of commodity j.

# APPENDIX 2: METHOD FOR CALCULATING NOMINAL RATES OF PROTECTION OF AGRICULTURAL COMMODITIES IN PAKISTAN

## Traded Commodities

### Wheat (Import Parity)

This series compares the procurement price with the import price nine months later, so world and border prices are prices for the next fiscal year.

The world price is c.i.f. Karachi, which equals the f.o.b. Gulf price (fourth quarter) based on No. 2 (ord.) hard winter wheat (International Wheat Council various years), plus the average freight cost for the shipping year from the Gulf to Karachi. Freight rates for years prior to 1975 were estimated from rates to East India, adjusted by a factor of 0.786 = freight to Karachi (1975) / freight to East India (1975) (International Wheat Council various years).

The border price is measured at the farmgate. It equals the world price times the nominal exchange rate plus import handling and transport from Karachi to Rawalpindi less the cost of transport from the farmgate to the wholesale market (including domestic handling, transport from the farmgate to Rawalpindi, and interest).

Import handling—the unloading cost in Karachi—is assumed to be the same as domestic handling. Transport by rail from Karachi to Rawalpindi includes other charges such as handling, bags, delivery, and storage. It is estimated for 1985 at Rs 207 per metric ton, based on data from Majeed (1985). Domestic handling is estimated for 1984 at Rs 228 per metric ton, and transport from the farmgate to Rawalpindi is estimated for 1984 at Rs 214 per metric ton (Majeed 1985). Interest, adjusted for the time lag between the harvest (March-April) and import (October-March), is calculated for nine months using fourth-quarter interest rates [see Table 31, (3)].

Handling and transport series were extended using the consumer price index (CPI) and the transport index, respectively [see Table 31, (1) and (2)].

### Wheat (Export Parity)

The world price is f.o.b. Karachi, which equals f.o.b. Gulf (second quarter) plus freight from Karachi to the Middle East (estimated to be half of freight from the Gulf to Karachi). It is based on f.o.b. Gulf No. 2 (ord.) hard winter wheat prices from *World Wheat Statistics* (International Wheat Council various years). The border price measured at the farmgate equals world price times the nominal exchange rate minus domestic handling, export handling, and transport from Karachi to the farmgate. The nominal exchange rate and domestic handling costs are derived in the same way as those for the import parity. Export handling is estimated for 1985 at Rs 160 per metric ton. Transport by road from the farmgate in Punjab to Karachi is estimated for 1985 at Rs 200 per metric ton, based on data from Majeed (1985).

### Basmati Rice (Milled)

The world price for milled basmati is the export unit value of Pakistan basmati rice based on FAO clean rice (Cheong 1964; World Bank 1988; Pakistan Ministry of Food, Agriculture and Cooperatives various years).

The border price is measured at the farmgate. It equals the world price times the nominal exchange rate less the cost from the farmgate to the wholesale market (including

## Table 31—Indices used in computing border prices for specific commodities, 1961-88

| Year | Commodity Price Indez (1) | Transport Index (2) | Interest Rate (3) | Exchange Rate (4) | Recovery Rate (5) | Freight Rate (6) |
|---|---|---|---|---|---|---|
| 1961 | 33.67 | 24.03 | 4.00 | 4.76 | 8.53 | 6.72 |
| 1962 | 33.83 | 24.03 | 4.00 | 4.77 | 8.53 | 6.84 |
| 1963 | 33.63 | 24.03 | 4.00 | 4.79 | 8.53 | 7.00 |
| 1964 | 35.04 | [illegible] | 4.00 | 4.79 | 8.53 | 9.88 |
| 1965 | 36.72 | [illegible] | 4.00 | 4.80 | 8.53 | 10.38 |
| 1966 | 37.65 | 24.03 | 5.00 | 4.79 | 8.53 | 11.28 |
| 1967 | 40.88 | 30.62 | 5.00 | 4.80 | 8.53 | 10.56 |
| 1968 | 42.34 | 32.56 | 5.00 | 4.79 | 8.53 | 13.52 |
| 1969 | 43.01 | 32.56 | 5.00 | 4.80 | 8.76 | 11.51 |
| 1970 | 44.78 | 36.39 | 5.00 | 4.79 | 7.52 | 12.30 |
| 1971 | 47.34 | 36.63 | 5.00 | 4.78 | 8.32 | 12.43 |
| 1972 | 49.57 | 36.54 | 5.00 | 5.56 | 8.60 | 8.24 |
| 1973 | 54.37 | 37.04 | 6.00 | 10.56 | 8.90 | 13.57 |
| 1974 | 70.67 | 55.16 | 8.00 | 9.90 | 8.70 | 36.52 |
| 1975 | 89.55 | 83.30 | 9.00 | 9.90 | 8.60 | 30.84 |
| 1976 | 100.00 | 100.00 | 9.00 | 9.90 | 8.30 | 15.33 |
| 1977 | 111.77 | 101.18 | 9.00 | 9.90 | 8.20 | 13.42 |
| 1978 | 120.48 | 94.13 | 10.00 | 9.90 | 8.80 | 14.50 |
| 1979 | 128.47 | 80.22 | 10.00 | 9.90 | 9.40 | 25.81 |
| 1980 | 142.23 | 94.72 | 10.00 | 9.90 | 9.40 | 36.58 |
| 1981 | 159.81 | 114.23 | 10.00 | 9.90 | 8.96 | 38.57 |
| 1982 | 175.79 | 121.12 | 10.00 | 10.55 | 8.69 | 38.69 |
| 1983 | 183.67 | 122.41 | 10.00 | 12.70 | 8.80 | 26.94 |
| 1984 | 199.03 | 132.63 | 10.00 | 13.48 | 8.40 | 26.08 |
| 1985 | 213.87 | 133.04 | 10.00 | 15.16 | 8.90 | 26.08 |
| 1986 | 224.21 | 133.41 | 10.00 | 16.13 | 8.70 | 26.09 |
| 1987 | 232.06 | 145.43 | 10.00 | 17.17 | 8.70 | 25.76 |
| 1988 | . . . | . . . | . . . | . . . | . . . | 26.68 |

Sources: The commodity price index and the transport index are from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years). The interest rate and the exchange rate are from the International Monetary Fund, *International Financial Statistics* (Washington, D.C.: IMF, various years). The recovery rate is from Pakistan, Ministry of Food, Agriculture and Cooperatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture, and Cooperatives, various years). The freight rate is from the International Wheat Council, *World Wheat Statistics* (London: IWC, various years).

export and domestic handling, transport from farmgate to Karachi, and interest).

The nominal exchange rate and domestic handling are derived in the same way as for wheat. Export handling is estimated for 1985 at Rs 160 per metric ton. Transport by road from the farmgate in Punjab to Karachi is estimated for 1985 at Rs 200 per metric ton based on data from Majeed (1985). Interest, adjusted for the time lag between harvest in November and the wholesale market in January, is calculated for three months [see Table 31, (3)].

### Basmati Rice (Unmilled)

The world price for unmilled basmati is the same as that for milled basmati rice.

The border price is measured at the farmgate. It equals the border price of milled rice less the milling cost times the milling rate. The milling cost is estimated to be the difference between the procurement price of milled rice and unmilled rice. The series was extended prior to 1976 using the CPI.

The milling rate equals 67 percent.

Handling and transport series were extended using the CPI and the transport index, respectively.

**Ordinary Rice (Milled)**

The world price for ordinary rice is f.o.b. Karachi. It equals the price for f.o.b. Thailand, 5 percent broken (FAO various years) with a 25 percent quality discount.

The border price is measured at the farmgate. It equals the world price times the nominal exchange rate less the cost from the farmgate to the wholesale market (including export and domestic handling, transport from the farmgate to Karachi, and interest). The nominal exchange rate and domestic handling are derived the same as for wheat. Export handling is the same as for basmati rice. Transport by road from the farmgate (Sind) to Karachi is estimated for 1984 at Rs 200 per metric ton (Majeed 1985). Interest, adjusted for the time lag between harvest (October) and the wholesale market (January), is calculated for three months [see Table 31, (3)].

**Ordinary Rice (Unmilled)**

The world price is derived in the same way as that for milled ordinary rice.

The border price is measured at the farmgate. It equals the border price of milled rice less milling cost times the milling rate. The milling cost is estimated to be the difference between the procurement price of milled and unmilled rice. The series was extended prior to 1976 using the CPI. The milling rate equals 67 percent.

The handling and transport series were extended using the CPI and the transport index, respectively.

**Sugarcane**

The world price is c.i.f. Karachi, which equals the f.o.b. Caribbean (second quarter) price plus freight (the same as for wheat) (International Monetary Fund various years b).

The border price is measured at the farmgate (Punjab). It equals the c.i.f. Karachi price times the nominal exchange rate plus domestic handling and transport (from Karachi to mill) times the recovery rate of sugarcane less the processing cost at the mill. The nominal exchange rate and the domestic handling cost are derived in the same way as those for wheat. Transport by rail from Karachi to the mill (Punjab), estimated for 1985, is Rs 207 per metric ton (Majeed 1985). The recovery rate is the country average [see Table 31, (5)]. The processing cost, estimated for 1986, is Rs 1.88 per kilogram of white sugar (Ilahi 1978).

**Sugar (Ex-mill)**

The world price for processed sugar is c.i.f. Karachi, which equals f.o.b. Caribbean (second quarter) plus freight (the same as for wheat) (International Monetary Fund various years b).

The border price, measured at the mill (Punjab), equals the c.i.f. Karachi price times the nominal exchange rate plus domestic handling and transport (from Karachi to the mill).

The nominal exchange rate and the domestic handling cost are derived in the same way as those for wheat. Like sugarcane, transport is by rail from Karachi to the mill.

The handling and transport series were extended using the CPI and the transport index, respectively.

**Fertilizer**

The world price of fertilizer is c.i.f. Karachi, which equals urea f.o.b. Europe (76 percent) and diammonium phosphate (DAP) f.o.b. Gulf (24 percent) plus freight (estimated the same as for wheat) (World Bank 1982).

The border price at the farmgate (Punjab) equals c.i.f. Karachi times the nominal exchange rate plus the domestic and retail handling and transport costs (from Karachi to the farmgate at Multan). The nominal exchange rate and the domestic handling cost are derived in the same way as those for wheat. The retail handling cost is derived in the same way as the domestic handling cost. Transport by rail from Karachi to the farmgate (Multan) is estimated for 1984 at Rs 123 per metric ton (Majeed 1985). Handling and transport cost series were extended using the CPI and the transport index, respectively.

**Seed Cotton**

The world price of seed cotton is f.o.b. Karachi, which equals the export unit value of cotton lint (NT/Sg) (FAO various years b).

The border price for seed cotton at the farmgate equals one-third the border price for lint cotton plus two-thirds the border price for cottonseed less transport from the farmgate to the ginning mill, which is estimated for 1985 at Rs 200 per metric ton.

The border price of lint cotton equals the f.o.b. Karachi price less export handling, transport from Karachi to the ginning mill, and the ginning cost.

Export handling is estimated for 1985 at Rs 36.25 per 40 kilograms (Pakistan, Agricultural Prices Commission 1985).

Transport from Karachi to the ginning mill is estimated for 1985 at Rs 24.25 per 40 kilograms (Pakistan, Agricultural Prices Commission 1985).

The ginning cost is estimated for 1983 at Rs 100 per 40 kilograms of lint cotton (Pakistan, Agricultural Prices Commission 1985).

The border price of cottonseed equals the border price of vegetable oil times the extraction rate of cottonseed less the processing cost. The extraction rate of cottonseed is 11 percent (USDA 1984, 271f). The processing cost is estimated for 1983 at Rs 6.45 per 40 kilograms of cottonseed (USDA 1984, 271f). The handling and transport series were extended using the CPI and the transport index, respectively.

**Maize**

The world price is c.i.f. Karachi, which equals the price for f.o.b. Gulf yellow No. 2 plus freight (estimated the same as for wheat) from the Gulf to Karachi (International Monetary Fund various years b).

The border price is measured at the farmgate. It equals the world price times the nominal exchange rate plus import handling and transport costs (from Karachi to Rawalpindi) less the transport cost from the farmgate to the wholesale market (including domestic handling and transport from the farmgate to Rawalpindi). The nominal exchange rate and other costs are derived in the same way as for wheat. These include import handling, transport by rail from Karachi to Rawalpindi, domestic handling, and transport from the farmgate to Rawalpindi. Handling and transport series were extended using the CPI and the transport index, respectively.

**Milk**

The world price is the unit import value of dry skim milk (Pakistan, Federal Bureau of Statistics various years).

The border price, measured at Karachi, equals the world price times the nominal exchange rate plus import handling, adjusted by a conversion ratio of 1:8 (1 kilogram of dry powder converts into 8 liters of milk), and a quality factor of 90 percent.

Import handling is estimated for 1987 at Rs 6.50 per kilogram. The quality factor is the ratio of the market price to the wholesale price. The market price equals the world price plus import handling, import duty, and other surcharges. The import duty, which includes other charges, is estimated for 1987 at Rs 11.50 per kilogram. Other surcharges include a 25 percent Iqra[33] surcharge and a 12.5 percent sales tax. These charges and the conversion rate are taken from three sources: Director of Agricultural Policy and Chemonics International (1988); Pakistan, Federal Bureau of Statistics (various years b); and Pakistan, Ministry of Finance (various years).

The domestic price is the wholesale price of milk in Karachi for 1987, extended for other years using the wholesale price index for milk. The import handling and duty series were extended using the CPI.

### Vegetable Oil

The world price is c.i.f. Karachi, which equals the price for soybean oil Dutch f.o.b. (50 percent) and for palm oil Malaysia f.o.b. (50 percent) plus freight (estimated the same as for wheat).

Soybean oil prices are taken from the International Monetary Fund's (IMF) *Yearbook* (various years c), and palm oil prices are from IMF's *Supplement on Prices* (various years b). The border price of refined oil at wholesale equals c.i.f. Karachi times the nominal exchange rate plus import handling and refining margin. The nominal exchange rate and import handling are derived in the same way as for wheat. The refining margin is estimated for 1983 at Rs 3.4 per kilogram (USDA, Office of International Cooperation and Development 1984). The domestic price of vegetable oil is the wholesale price of cottonseed oil. Handling charges and the refining margin series are extended using the CPI.

## Nontraded Commodities

### Pulses

The pulses included are gram, masoor, mung, and mash.

The wholesale price Karachi is a weighted average of wholesale prices from the *Agricultural Statistics of Pakistan* (Pakistan, Ministry of Food, Agriculture and Co-operatives various years). Weights are the production shares of these pulses.

### Millet and Sorghum

This category includes bajra and jowar. The wholesale price Karachi for millet and sorghum is a weighted average of the wholesale prices from the *Agricultural Statistics of Pakistan* (Pakistan, Ministry of Food, Agriculture and Co-operatives various years). Weights are the production shares.

### Meat

Meat includes beef.

The wholesale price Karachi is an extended series of the wholesale price for 1986/87 from Pakistan, Federal Bureau of Statistics (various years b), using the wholesale price index for meat (Pakistan, Federal Bureau of Statistics various years b).

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[33] Iqra is a surcharge on internationally traded goods.

### Fruits

The wholesale price Karachi for fruits is computed from the total value of production divided by the total production of fruits. The value of production for each fruit is derived from the unit value of each fruit and production data taken from Pakistan, Agricultural and Livestock Marketing Advisor (1981).

The values of the fruits included are mangoes, Rs 5,668; bananas, Rs 1,859; apples, Rs 12,941; guava, Rs 2,551; and dates, Rs 3,530.

# APPENDIX 3: METHODOLOGY FOR EFFECTIVE RATES OF PROTECTION

Cost of production estimates used to calculate value added for wheat, cotton, basmati rice, and ordinary rice are based on data from the Pakistan Agricultural Prices Commission (1986) on average costs of all farmers in the Punjab in the 1982/83 cropping year. For sugarcane, the cost of production is based on data for 1975 from Ilahi (1978).

In order to construct time series of the costs of production, constant technology and yields were assumed. Therefore, changes in cost of production were derived from changes in input prices only. A time series of the cost of fertilizer was constructed using an index of the retail price of fertilizer:

$$P_f(t) = P_f(1983) \cdot PFI(t)/PFI(1983), \qquad (35)$$

where $P_f(t)$ is the cost of fertilizer in year t, and PFI(t) is the index of retail prices of fertilizer in year t.

Time series for plant protection, canal and tubewell irrigation, and tractor (tillage) costs were constructed in the same way, using an index of the price of nonagricultural goods and services $[P_{na}(t)]$. A time series for the cost of manure was constructed using an index of prices of nontradables, the consumer price index (CPI).

The value of by-products was assumed to be a constant percentage of the value of the harvest; seed costs were assumed to vary with the price of output. For cotton, seed costs were assumed to vary with the price of cottonseed, which was derived from the price of cottonseed oil (see Appendix 2).

In calculating the cost of production under free trade and no change in exchange rates, prices of all inputs except goods with essentially no tradable component (such as manure) were assumed to change. The new fertilizer price series was constructed using the free-trade price of fertilizer PFI′(t) instead of PFI(t). Seed costs were calculated using the free-trade prices of output. Time series of plant protection, canal and tubewell irrigation, and tractor (tillage) costs, C(i,t), were estimated using $P'_{na}(t)$, the index of free-trade prices of nonagricultural goods and services:

$$C(i,t)' = C(i,t) \cdot P'_{na}(t)/P_{na}(t). \qquad (36)$$

Cost of production figures under free trade with equilibrium exchange rates were constructed in a similar manner using PFI(t)* and $P_{na}(t)^*$ instead of PFI(t)′ and $P_{na}(t)'$.

The price indices for nonagricultural goods and services were calculated as follows.

$$P_{na}(t) = w1 \cdot P_{mna}(t) + w2 \cdot P_{xna}(t) + (1 - w1 - w2) \cdot P_{nt}(t), \qquad (37)$$

where

$P_{na}(t)$ = price index of the nonagricultural sector in year t;

$P_{mna}(t)$ = price index of nonagricultural imports in year t, a weighted average of the domestic prices of nonagricultural imports, which were used in the computation of $(1 + t_m)$ in Table 26 (see also Chapter 4, equation 3);

$P_{xna}(t)$ = price index of nonagricultural exports in year t, a weighted average of the domestic prices of nonagricultural exports, which were used in the computation of $(1 - t_x)$ in Table 26 (see also Chapter 4, equation 4);

$P_{nt}$ = price index of nonagricultural nontradables in year t; the Pakistan CPI was used as a proxy.

The weights w1 (= 0.05) and w2 (= 0.20), the shares of nonagricultural importables and exportables in nonagricultural value added, were estimated using 1980/81 data for GDP and nonagriculture value added from the Pakistan Economic Survey for 1987-88 (Pakistan, Ministry of Finance 1988). The nonagricultural export sector was estimated as value added in textiles, wearing apparel, cotton ginning, and sports equipment. The remainder of value added in manufacturing was assigned to the nonagricultural import sector.

$$P'_{na}(t) = w1 \cdot E \cdot P_{mna\$}(t) + w2 \cdot E \cdot P_{xna\$}(t) + (1 - w1 - w2) \cdot P_{nt}(t), \tag{38}$$

and

$$P^*_{na}(t) = w1 \cdot E^* \cdot P_{mna\$}(t) + w2 \cdot E^* \cdot P_{xna\$}(t) + (1 - w1 - w2) \cdot P_{nt}(t), \tag{39}$$

where

$P'_{na}(t)$ = price index of the nonagricultural sector evaluated at the official exchange rate in year t,

$P^*_{na}(t)$ = price index of the nonagricultural sector evaluated at the equilibrium exchange rate in year t, and

$P_{mna\$}(t)$ = index of prices in U.S. dollars.

$$P_{mna\$} = (P_{m\$} - d1\, P_{ma\$})/(1 - d1), \tag{40}$$

d1 = 0.20;

$$P_{ma\$} = b1 \cdot P_{wheat\$} + (1 - b1) \cdot P_{vegoil\$}, \tag{41}$$

b1 = 0.77 for 1960-71 and 0.50 for 1972-87,

$$P_{xna\$} = (P_{x\$} - e1\, P_{xa\$})/(1 - e1), \tag{42}$$

e1 = 0.05;

and

$$P_{xa\$} = c1 \cdot P_{cotton\$} + (1 - c1) \cdot P_{rice\$}, \tag{43}$$

c1 = 0.70 for 1960-71 and 0.48 for 1972-87;

where $P_{m\$}$ = price index of imports and $P_{x\$}$ = price index of exports, used in the construction of $(1 + t_m)$ and $(1 - t_x)$ (see Table 24), E = official exchange rate, and $E^*$ = equilibrium exchange rate.

Time series for $P_{na}$, $P'_{na}$, and $P^*_{na}$ are presented in Table 32.

## Table 32—Indices of nonagricultural prices, 1961-87

| Year | $P_{na}$ | $P'_{na}$ | $P^*_{na}$ | $P'_{na}/P_{na}$ | $P^*_{na}/P_{na}$ |
|---|---|---|---|---|---|
| 1961 | 19.39 | 16.90 | 18.46 | 87.18 | 95.23 |
| 1962 | 19.85 | 17.32 | 18.85 | 87.23 | 94.97 |
| 1963 | 19.56 | 16.95 | 18.52 | 86.62 | 94.66 |
| 1964 | 20.44 | 17.74 | 19.42 | 86.77 | 94.99 |
| 1965 | 21.20 | 18.27 | 20.07 | 86.16 | 94.68 |
| 1966 | 21.77 | 18.80 | 20.59 | 86.36 | 94.57 |
| 1967 | 23.82 | 20.81 | 22.84 | 87.37 | 95.86 |
| 1968 | 24.63 | 21.39 | 23.58 | 86.87 | 95.74 |
| 1969 | 25.21 | 21.61 | 23.99 | 85.69 | 95.13 |
| 1970 | 26.55 | 22.83 | 25.16 | 85.99 | 94.76 |
| 1971 | 28.35 | 24.27 | 26.87 | 85.59 | 94.79 |
| 1972 | 30.38 | 26.32 | 29.30 | 86.63 | 96.45 |
| 1973 | 33.43 | 30.78 | 32.14 | 92.07 | 96.16 |
| 1974 | 43.81 | 41.38 | 42.12 | 94.45 | 96.14 |
| 1975 | 55.12 | 52.33 | 53.36 | 94.94 | 96.82 |
| 1976 | 61.71 | 57.71 | 60.71 | 93.52 | 98.37 |
| 1977 | 67.12 | 62.45 | 65.99 | 93.04 | 98.31 |
| 1978 | 71.51 | 67.70 | 71.23 | 94.67 | 99.61 |
| 1979 | 76.47 | 71.91 | 74.84 | 94.03 | 97.86 |
| 1980 | 87.19 | 80.84 | 84.25 | 92.71 | 96.62 |
| 1981 | 100.00 | 91.78 | 96.51 | 91.78 | 96.51 |
| 1982 | 108.41 | 101.65 | 106.24 | 93.76 | 98.00 |
| 1983 | 113.32 | 106.27 | 110.65 | 93.78 | 97.64 |
| 1984 | 122.53 | 113.83 | 119.49 | 92.90 | 97.51 |
| 1985 | 129.22 | 120.76 | 125.29 | 93.45 | 96.95 |
| 1986 | 134.68 | 125.23 | 131.04 | 92.98 | 97.29 |
| 1987 | 138.20 | 129.90 | 134.72 | 93.99 | 97.48 |

Source: Authors' computations based on data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years).

Notes: $P_{na}$ = the price index of nonagriculture,
$P'_{na}$ = the price index of nonagriculture, with free trade at the official exchange rate.
$P^*_{na}$ = the price index of nonagriculture with free trade and an equilibrium exchange rate.

# APPENDIX 4: MODELING WORLD DEMAND FOR BASMATI RICE

Essentially all of the basmati rice traded on the world market is exported from Pakistan to countries in the Middle East. Thus Pakistan's annual exports are equal to total export demand for basmati rice (apart from changes in stocks and losses).

Clearly, Pakistan is not a price-taker in the world market for basmati rice, and changes in the level of Pakistan's exports are likely to have a significant effect on the world price.

World demand for basmati rice is assumed to be a function of the per capita income of the Middle Eastern importing countries and the ratio of the world prices of basmati rice to the world price of ordinary rice. Equation (44) shows the results of a regression on annual time series data from 1972 to 1987.

$$\underset{(1.79)}{QD = 1.037} - \underset{(-2.22)}{0.533} \cdot BSMORD + \underset{(3.70)}{0.422} \cdot PERGDP; \qquad (44)$$

$$D.W. = 1.85, \quad R^2 = 0.42;$$

where

QD = log(Pakistan export volume of basmati rice per capita),[34]

BSMORD = log(world price of basmati/world price of ordinary rice), and

PERGDP = log(Saudi Arabia GDP per capita deflated by the CPI).

Data used for this regression are shown in Table 33. The world price of basmati rice is f.o.b. Karachi plus the cost of freight from Karachi to the Middle East (estimated to be half of the cost of freight from the Gulf of Mexico to Karachi (see the freight rates in Appendix 2, Table 31). The world price of ordinary rice is f.o.b. Karachi (see the section on ordinary rice in Appendix 2).

For the model presented in Chapter 7, equation (44) was modified in two ways. First, the equation was linearized around the mean export value in order to make solution of the model easier. Second, it was assumed that the world price of basmati rice could not fall lower than 1.6 times the world price of ordinary rice (the price differential represents an estimated quality differential between basmati and ordinary rice).

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[34] The population includes the major countries importing Basmati rice: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

## Table 33—Data used in the regression on world demand for basmati rice, 1972-87

| Year | World Price of Basmati Rice | World Price of Ordinary Rice | Per Capita GDP of Saudi Arabia, Adjusted by CPI | Per Capita Demand for Basmati Rice |
|---|---|---|---|---|
| | (US$/metric ton) | | (1970 = 100) | (kilograms/capita) |
| 1972 | 272.78 | 98.50 | 127.45 | 19.98 |
| 1973 | 260.99 | 146.50 | 122.81 | 6.59 |
| 1974 | 552.12 | 428.25 | 326.49 | 18.63 |
| 1975 | 800.85 | 299.25 | 345.38 | 15.39 |
| 1976 | 531.08 | 193.75 | 294.17 | 29.12 |
| 1977 | 352.71 | 194.50 | 275.57 | 45.45 |
| 1978 | 374.04 | 277.00 | 274.05 | 25.02 |
| 1979 | 759.12 | 228.25 | 291.62 | 14.42 |
| 1980 | 734.57 | 302.25 | 422.85 | 23.70 |
| 1981 | 728.08 | 363.75 | 526.48 | 29.40 |
| 1982 | 727.48 | 248.00 | 499.44 | 17.96 |
| 1983 | 637.61 | 203.00 | 380.02 | 15.61 |
| 1984 | 613.79 | 190.75 | 334.12 | 25.57 |
| 1985 | 637.58 | 166.50 | 289.04 | 10.52 |
| 1986 | 671.81 | 171.50 | 249.44 | 15.08 |
| 1987 | 730.24 | 154.28 | 212.53 | 10.47 |

Source: International Monetary Fund, *International Financial Statistics* (Washington, D.C.: IMF, various years).

# APPENDIX 5: SIMULATION RESULTS

## Table 34—Agricultural production (simulation 1)

| Commodity/ Period | Area 1 | Change | Yield 1 | Change | Production 1 | Change |
|---|---|---|---|---|---|---|
| | (1,000 hectares) | (percent) | (metric tons/ hectare) | (percent) | (1,000 metric tons | (percent) |
| Wheat | | | | | | |
| 1961-65 | 4,885.8 | −1.97 | 0.81 | −2.87 | 3,953.7 | −4.79 |
| 1966-71 | 5,507.2 | −5.18 | 0.95 | −4.70 | 5,272.7 | −9.76 |
| 1972-77 | 6,400.9 | 6.11 | 1.55 | 18.60 | 10,111.6 | 27.81 |
| 1978-82 | 7,168.4 | 4.87 | 1.76 | 15.78 | 12,638.9 | 21.64 |
| 1983-87 | 7,528.7 | 1.85 | 1.86 | 8.99 | 14,008.1 | 10.87 |
| 1961-87 | 6,272.7 | 1.36 | 1.38 | 8.87 | 9,085.5 | 12.31 |
| Basmati rice | | | | | | |
| 1961-65 | 484.4 | 29.75 | 0.93 | 7.57 | 456.5 | 40.54 |
| 1966-71 | 664.5 | 50.21 | 1.05 | 1.37 | 707.9 | 52.95 |
| 1972-77 | 551.2 | 26.96 | 1.43 | 18.47 | 833.0 | 58.93 |
| 1978-82 | 843.4 | 15.87 | 1.35 | 12.85 | 1,158.9 | 32.92 |
| 1983-87 | 1,055.6 | 30.90 | 1.31 | 8.85 | 1,388.0 | 42.42 |
| 1961-87 | 711.5 | 29.82 | 1.22 | 10.23 | 898.6 | 44.61 |
| Ordinary rice | | | | | | |
| 1961-65 | 856.3 | −1.71 | 0.95 | −0.50 | 817.1 | −2.19 |
| 1966-71 | 1,145.0 | 9.97 | 1.26 | 1.04 | 1,480.9 | 12.96 |
| 1972-77 | 1,386.6 | 21.35 | 2.14 | 28.44 | 3,011.7 | 58.21 |
| 1978-82 | 1,461.0 | 17.27 | 2.28 | 21.62 | 3,308.4 | 42.22 |
| 1983-87 | 1,287.4 | 4.65 | 1.99 | 4.18 | 2,552.2 | 9.39 |
| 1961-87 | 1,230.1 | 11.31 | 1.72 | 12.93 | 2,235.0 | 29.05 |
| Maize | | | | | | |
| 1961-65 | 463.9 | −3.28 | 0.96 | −6.35 | 447.2 | −9.47 |
| 1966-71 | 604.1 | 0.50 | 0.94 | −13.48 | 568.5 | −13.19 |
| 1972-77 | 733.6 | 16.82 | 1.43 | 19.96 | 1,074.7 | 43.57 |
| 1978-82 | 708.0 | 0.70 | 1.31 | 4.89 | 930.3 | 5.83 |
| 1983-87 | 812.4 | 1.16 | 1.29 | 0.04 | 1,046.2 | 1.24 |
| 1961-87 | 664.7 | 3.72 | 1.19 | 1.68 | 814.0 | 7.45 |
| Millet and sorghum | | | | | | |
| 1961-65 | 1,349.8 | 2.15 | 0.48 | −0.37 | 642.7 | 1.82 |
| 1966-71 | 1,399.3 | 5.38 | 0.46 | −5.81 | 639.6 | −0.53 |
| 1972-77 | 1,183.0 | 3.09 | 0.55 | 3.30 | 663.8 | 7.67 |
| 1978-82 | 1,009.8 | 0.49 | 0.55 | 5.20 | 558.5 | 5.80 |
| 1983-87 | 923.7 | 1.66 | 0.52 | 0.38 | 482.5 | 2.17 |
| 1961-87 | 1,181.9 | 2.85 | 0.51 | 0.54 | 601.4 | 3.34 |
| Sugarcane | | | | | | |
| 1961-65 | 334.7 | −28.61 | 29.12 | −13.85 | 9,747.5 | −38.50 |
| 1966-71 | 184.8 | −68.75 | 22.30 | −41.06 | 4,128.9 | −81.58 |
| 1972-77 | 697.0 | 7.45 | 44.96 | 24.88 | 31,340.5 | 34.19 |
| 1978-82 | 844.4 | 3.87 | 40.20 | 9.00 | 33,943.9 | 13.27 |
| 1983-87 | 562.7 | −34.01 | 31.14 | −15.38 | 17,523.2 | −44.16 |
| 1961-87 | 518.5 | −22.70 | 33.55 | −7.27 | 19,218.1 | −21.45 |
| Cotton | | | | | | |
| 1961-65 | 1,416.5 | 1.17 | 0.24 | −4.37 | 346.7 | −3.05 |
| 1966-71 | 1,806.2 | 6.24 | 0.25 | −15.45 | 450.4 | −9.95 |
| 1972-77 | 1,786.3 | −7.28 | 0.30 | −3.84 | 545.2 | −10.40 |
| 1978-82 | 2,008.3 | −0.95 | 0.33 | 3.17 | 662.7 | 2.29 |
| 1983-87 | 2,512.9 | 8.43 | 0.42 | −0.09 | 1,072.3 | 10.27 |
| 1961-87 | 1,897.9 | 1.50 | 0.31 | −4.09 | 606.7 | −0.96 |

*(continued)*

## Table 34—Continued

| Commodity/ Period | Area 1 | Change | Yield 1 | Change | Production 1 | Change |
|---|---|---|---|---|---|---|
| | (1,000 hectares) | (percent) | (metric tons/ hectare) | (percent) | (1,000 metric tons | (percent) |
| Vegetable oil | | | | | | |
| 1961-65 | 579.2 | 9.64 | 0.16 | -0.33 | 93.9 | 9.59 |
| 1966-71 | 693.4 | 27.52 | 0.17 | -10.75 | 121.8 | 14.34 |
| 1972-77 | 587.8 | 0.79 | 0.22 | 4.09 | 131.1 | 4.35 |
| 1978-82 | 625.1 | 24.63 | 0.28 | 19.70 | 174.8 | 49.55 |
| 1983-87 | 667.5 | 50.54 | 0.32 | 19.61 | 215.5 | 80.38 |
| 1961-87 | 631.4 | 20.65 | 0.23 | 7.23 | 145.9 | 31.14 |
| Pulses | | | | | | |
| 1961-65 | 1,374.8 | 1.49 | 0.53 | -0.71 | 726.2 | 0.74 |
| 1966-71 | 1,342.4 | 7.38 | 0.47 | -4.83 | 634.4 | 2.45 |
| 1972-77 | 1,493.5 | 0.81 | 0.52 | -0.23 | 776.8 | 0.42 |
| 1978-82 | 1,409.7 | -4.04 | 0.42 | 1.08 | 594.7 | -3.25 |
| 1983-87 | 1,377.4 | -1.64 | 0.53 | -0.45 | 732.8 | -2.10 |
| 1961-87 | 1,401.0 | 0.84 | 0.50 | -1.18 | 693.9 | -0.22 |
| Fruits | | | | | | |
| 1961-65 | 112.7 | -1.64 | 8.24 | -2.22 | 927.8 | -3.83 |
| 1966-71 | 158.8 | 2.99 | 8.74 | -5.34 | 1,385.7 | -2.69 |
| 1972-77 | 185.6 | 2.25 | 9.68 | 0.18 | 1,802.2 | 2.66 |
| 1978-82 | 219.2 | -6.41 | 9.14 | -1.09 | 2,008.1 | -7.37 |
| 1983-87 | 315.1 | -7.20 | 8.93 | -2.45 | 2,806.8 | -9.55 |
| 1961-87 | 196.3 | -2.83 | 8.97 | -2.18 | 1,771.9 | -4.80 |
| Milk | | | | | | |
| 1961-65 | ... | ... | ... | ... | 6,457.6 | -2.82 |
| 1966-71 | ... | ... | ... | ... | 6,879.8 | -6.16 |
| 1972-77 | ... | ... | ... | ... | 7,667.4 | -5.74 |
| 1978-82 | ... | ... | ... | ... | 5,256.5 | -42.10 |
| 1983-87 | ... | ... | ... | ... | 6,452.1 | -40.76 |
| 1961-87 | ... | ... | ... | ... | 6,596.8 | -21.15 |
| Meat | | | | | | |
| 1961-65 | ... | ... | ... | ... | 388.7 | -2.74 |
| 1966-71 | ... | ... | ... | ... | 473.4 | -4.60 |
| 1972-77 | ... | ... | ... | ... | 646.7 | 1.28 |
| 1978-82 | ... | ... | ... | ... | 709.6 | -13.48 |
| 1983-87 | ... | ... | ... | ... | 962.9 | -11.04 |
| 1961-87 | ... | ... | ... | ... | 630.6 | -7.06 |

Sources: Authors' calculations based on data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years); and Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years).

Notes: For wheat, maize, millet and sorghum, production and yield are expressed in terms of unmilled grain. For basmati and ordinary rice, production and yield are expressed in terms of millet rice (the conversion factor is 67 percent). For sugarcane, production and yield are expressed in terms of refined sugar. For cotton, production and yield are expressed in terms of lint cotton. For vegetable oil, area includes areas of rape and mustard, groundnuts, and sesamum seeds. Production and yield are expressed in terms of oil (using extraction rates of 34 percent for rape and mustard seed oil, 45 percent for groundnuts, and 40 percent for sesamum seed oil). For pulses, production and yield are expressed in terms of unmilled grains of grams and other pulses. For fruits, area, production, and yield include citrus fruits, mangoes, bananas, apples, guava, dates, apricots, peaches, pears, grapes, and pomegranates. For milk, production is expressed in terms of whole milk. For meat, production includes beef, mutton, and poultry. Change indicates percent change relative to historical levels.

## Table 35—Consumer prices, consumption, and trade (simulation 1)

| Commodity/ Period | Consumer Prices 1 | Change | Consumption 1 | Change | Trade 1 | Historical Trade |
|---|---|---|---|---|---|---|
| | (Rs/metric ton) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | |
| Wheat | | | | | | |
| 1961-65 | [illegible]32.7 | -1.1 | 4,638.6 | -1.24 | -1,080.3 | -959.2 |
| 1966-71 | 449.0 | -14.3 | 5,925.4 | 0.45 | -1,180.0 | -640.3 |
| 1972-77 | 1,572.8 | 77.2 | 7,372.2 | -9.78 | 1,728.3 | -1,051.2 |
| 1978-82 | 2,347.6 | 61.8 | 9,019.7 | -12.11 | 2,355.4 | -911.0 |
| 1983-87 | 2,799.6 | 38.4 | 10,862.6 | -10.79 | 1,744.6 | -805.2 |
| 1961-87 | 1,482.6 | 42.8 | 7,495.9 | -8.05 | 681.1 | -871.3 |
| Basmati rice | | | | | | |
| 1961-65 | 1,006.1 | 17.2 | 201.6 | -15.28 | 209.2 | 54.4 |
| 1966-71 | 968.1 | -7.3 | 294.7 | -1.55 | 342.5 | 117.3 |
| 1972-77 | 3,511.4 | 46.7 | 246.5 | 2.26 | 503.2 | 230.7 |
| 1978-82 | 5,337.5 | 19.7 | 495.3 | 0.75 | 547.7 | 293.0 |
| 1983-87 | 6,640.4 | 6.7 | 610.5 | -2.15 | 638.7 | 253.2 |
| 1961-87 | 3,399.9 | 17.2 | 362.4 | -2.26 | 446.4 | 188.5 |
| Ordinary rice | | | | | | |
| 1961-65 | 490.4 | -7.0 | 710.5 | 4.25 | 24.8 | 70.2 |
| 1966-71 | 576.3 | -4.9 | 1,150.4 | -0.75 | 182.4 | 20.8 |
| 1972-77 | 2,173.4 | 101.3 | 1,175.6 | -10.43 | 1,534.9 | 400.7 |
| 1978-82 | 2,748.3 | 49.3 | 1,267.5 | -6.22 | 1,710.0 | 742.1 |
| 1983-87 | 2,508.6 | -4.9 | 1,348.8 | 7.32 | 948.2 | 842.9 |
| 1961-87 | 1,675.4 | 28.7 | 1,133.0 | -2.20 | 878.5 | 400.2 |
| Maize | | | | | | |
| 1961-65 | 268.2 | -18.5 | 468.5 | 5.37 | -66.0 | 0.0 |
| 1966-71 | 298.1 | -26.5 | 620.3 | 5.25 | -108.7 | 0.0 |
| 1972-77 | 1,200.1 | 65.8 | 644.1 | -4.40 | 323.1 | 0.0 |
| 1978-82 | 1,323.8 | 0.6 | 852.0 | 7.69 | -14.8 | 0.0 |
| 1983-87 | 1,739.3 | -6.7 | 989.2 | 6.36 | -47.6 | 0.0 |
| 1961-87 | 949.8 | 5.4 | 708.7 | 3.95 | 23.9 | 0.0 |
| Millet and sorghum | | | | | | |
| 1961-65 | 379.4 | -5.0 | 578.5 | 1.83 | ... | ... |
| 1966-71 | 417.4 | -13.1 | 575.6 | -0.52 | ... | ... |
| 1972-77 | 1,061.6 | 14.4 | 597.3 | 7.65 | ... | ... |
| 1978-82 | 1,816.6 | 3.6 | 502.7 | 5.81 | ... | ... |
| 1983-87 | 2,710.4 | 2.5 | 434.5 | 2.24 | ... | ... |
| 1961-87 | 1,237.3 | 3.0 | 541.3 | 3.35 | ... | ... |
| Sugarcane | | | | | | |
| 1961-65 | 606.9 | -63.0 | 1,930.8 | 54.82 | -1,182.5 | -30.4 |
| 1966-71 | 468.1 | -73.3 | 2,889.2 | 68.13 | -2,576.7 | -37.7 |
| 1972-77 | 3,093.1 | -4.6 | 2,066.7 | 12.66 | 304.4 | -43.3 |
| 1978-82 | 3,752.9 | -28.0 | 2,984.5 | 21.07 | -251.6 | -34.6 |
| 1983-87 | 2,940.8 | -63.5 | 3,663.9 | 49.15 | -2,293.6 | -0.6 |
| 1961-87 | 2,143.3 | -44.6 | 2,690.0 | 39.25 | -1,195.3 | -30.1 |
| Cotton | | | | | | |
| 1961-65 | 2,221.3 | -2.0 | 192.4 | -3.80 | 119.6 | 121.8 |
| 1966-71 | 2,236.4 | -4.4 | 312.0 | -3.44 | 93.3 | 127.0 |
| 1972-77 | 8,317.4 | 35.1 | 422.1 | 1.06 | 68.6 | 130.0 |
| 1978-82 | 12,313.7 | 11.7 | 377.6 | -3.29 | 218.8 | 192.6 |
| 1983-87 | 13,619.7 | -2.3 | 484.7 | -1.37 | 480.4 | 383.8 |
| 1961-87 | 7,559.1 | 9.1 | 358.5 | -1.79 | 187.6 | 186.4 |
| Vegetable oil | | | | | | |
| 1961-65 | 1,934.2 | 16.8 | 129.0 | -16.74 | -21.6 | -54.2 |
| 1966-71 | 2,089.8 | -8.8 | 179.5 | -6.63 | -40.2 | -63.4 |
| 1972-77 | 6,467.4 | -10.7 | 391.8 | 18.48 | -237.8 | -177.5 |
| 1978-82 | 9,359.0 | -12.5 | 597.3 | 7.81 | -396.3 | -406.1 |
| 1983-87 | 11,740.1 | -10.4 | 849.0 | -0.36 | -584.3 | -680.4 |
| 1961-87 | 6,167.0 | -9.7 | 418.7 | 3.30 | -247.4 | -264.8 |

*(continued)*

## Table 35—Continued

| **Commodity/ Period** | **Consumer Prices 1** | **Change** | **Consumption 1** | **Change** | **Trade 1** | **Historical Trade** |
|---|---|---|---|---|---|---|
| | (Rs/metric ton) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | |
| Pulses | | | | | | |
| 1961-65 | 457.1 | -5.0 | 653.6 | 0.74 | ... | ... |
| 1966-71 | 618.1 | -11.9 | 571.0 | 2.45 | ... | ... |
| 1972-77 | 1,297.3 | 1.0 | 699.1 | 0.42 | ... | ... |
| 1978-82 | 3,931.2 | 3.7 | 535.2 | -3.24 | ... | ... |
| 1983-87 | 5,191.0 | -2.6 | 659.6 | -2.08 | ... | ... |
| 1961-87 | 2,199.6 | -0.9 | 624.5 | -0.22 | ... | ... |
| Fruits | | | | | | |
| 1961-65 | 707.6 | -19.1 | 835.0 | -3.84 | ... | ... |
| 1966-71 | 812.1 | -27.7 | 1,247.1 | -2.69 | ... | ... |
| 1972-77 | 2,202.9 | 5.5 | 1,622.2 | 2.68 | ... | ... |
| 1978-82 | 3,614.8 | -3.3 | 1,807.4 | -7.37 | ... | ... |
| 1983-87 | 4,285.5 | -16.7 | 2,526.4 | -9.54 | ... | ... |
| 1961-87 | 2,264.0 | -10.2 | 1,594.8 | -4.80 | ... | ... |
| Milk | | | | | | |
| 1961-65 | 693.7 | -2.0 | 5,811.6 | -3.68 | 0.2 | -53.0 |
| 1966-71 | 890.3 | 2.5 | 6,191.6 | -6.90 | 0.2 | -52.3 |
| 1972-77 | 1,365.3 | -31.5 | 9,461.1 | 28.33 | -2,560.5 | -51.0 |
| 1978-82 | 1,924.2 | -41.7 | 11,544.8 | 38.13 | -6,814.0 | -186.4 |
| 1983-87 | 3,045.2 | -39.6 | 12,736.1 | 27.35 | -6,929.3 | -198.5 |
| 1961-87 | 1,550.0 | -32.9 | 9,051.1 | 18.57 | -3,113.9 | -104.1 |
| Meat | | | | | | |
| 1961-65 | 1,138.7 | -0.7 | 349.8 | -2.74 | ... | ... |
| 1966-71 | 1,668.0 | 4.3 | 426.1 | -4.60 | ... | ... |
| 1972-77 | 3,398.5 | -7.1 | 582.0 | 1.29 | ... | ... |
| 1978-82 | 7,520.7 | 3.6 | 638.7 | -13.48 | ... | ... |
| 1983-87 | 10,758.3 | -0.2 | 866.4 | -11.06 | ... | ... |
| 1961-87 | 4,721.8 | 0.0 | 567.5 | -7.06 | ... | ... |

Sources: Model simulations and data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years); and Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years).

Notes: For wheat and maize, trade is expressed in terms of unmilled grain. For basmati and ordinary rice, trade is expressed in terms of milled rice. For sugarcane, trade is expressed in terms of refined sugar. For cotton, trade is expressed in terms of lint cotton. For vegetable oil, trade includes soybean oil, palm oil, and cotton oil. For milk, trade is expressed in terms of whole milk (dry milk is converted, using a quality factor of 90 percent and a conversion ratio of 1:8). Milk was not traded prior to 1971. Millet and sorghum, fruits, meat, and pulses are nontradables. Change indicates percent change relative to historical levels.

## Table 36—Agricultural production (simulation 2)

| Commodity/ Period | Area 2 | Change | Yield 2 | Change | Production 2 | Change |
|---|---|---|---|---|---|---|
| | (1,000 hectares) | (percent) | (metric tons/ hectare) | (percent) | (1,000 metric tons) | (percent) |
| Wheat | | | | | | |
| 1961-65 | 5,263.8 | 5.61 | 0.91 | 9.74 | 4,834.9 | 16.43 |
| 1966-71 | 6,372.4 | 9.72 | 1.16 | 16.68 | 7,492.6 | 28.24 |
| 1972-77 | 7,128.6 | 18.18 | 1.81 | 38.04 | 12,972.0 | 63.96 |
| 1978-82 | 7,580.6 | 10.90 | 1.89 | 24.40 | 14,351.6 | 38.12 |
| 1983-87 | 7,891.5 | 6.76 | 1.98 | 15.95 | 15,621.3 | 23.64 |
| 1961-87 | 6,840.2 | 10.53 | 1.54 | 22.28 | 10,993.6 | 35.90 |
| Basmati rice | | | | | | |
| 1961-65 | 596.8 | 59.84 | 1.15 | 31.97 | 704.3 | 116.79 |
| 1966-71 | 931.5 | 110.56 | 1.54 | 47.93 | 1,457.6 | 214.91 |
| 1972-77 | 643.2 | 48.16 | 1.64 | 35.98 | 1,063.8 | 102.96 |
| 1978-82 | 916.3 | 25.89 | 1.47 | 23.12 | 1,361.5 | 56.16 |
| 1983-87 | 1,070.3 | 32.71 | 1.39 | 14.89 | 1,485.9 | 52.46 |
| 1961-87 | 828.4 | 51.14 | 1.45 | 31.05 | 1,218.0 | 96.00 |
| Ordinary rice | | | | | | |
| 1961-65 | 926.2 | 6.31 | 1.16 | 21.50 | 1,088.7 | 30.33 |
| 1966-71 | 1,277.2 | 22.66 | 1.77 | 42.16 | 2,314.3 | 76.54 |
| 1972-77 | 1,503.5 | 31.58 | 2.46 | 47.52 | 3,709.8 | 94.88 |
| 1978-82 | 1,554.5 | 24.77 | 2.52 | 34.34 | 3,894.1 | 67.40 |
| 1983-87 | 1,380.9 | 12.26 | 2.18 | 14.14 | 3,000.1 | 28.59 |
| 1961-87 | 1,333.0 | 20.62 | 2.02 | 32.78 | 2,817.0 | 62.66 |
| Maize | | | | | | |
| 1961-65 | 514.4 | 7.27 | 1.16 | 12.61 | 600.2 | 21.50 |
| 1966-71 | 741.1 | 23.29 | 1.34 | 22.78 | 990.2 | 51.20 |
| 1972-77 | 892.9 | 42.19 | 1.74 | 45.92 | 1,569.3 | 109.65 |
| 1978-82 | 781.0 | 11.08 | 1.45 | 16.21 | 1,136.6 | 29.29 |
| 1983-87 | 909.2 | 13.21 | 1.46 | 13.77 | 1,333.4 | 29.03 |
| 1961-87 | 771.4 | 20.36 | 1.44 | 23.23 | 1,137.3 | 50.14 |
| Millet and sorghum | | | | | | |
| 1961-65 | 1,348.6 | 2.06 | 0.50 | 5.26 | 679.4 | 7.63 |
| 1966-71 | 1,340.0 | 0.92 | 0.50 | 3.43 | 672.6 | 4.60 |
| 1972-77 | 1,131.9 | -1.36 | 0.56 | 4.30 | 639.1 | 3.68 |
| 1978-82 | 1,006.3 | 0.14 | 0.56 | 6.75 | 564.5 | 6.94 |
| 1983-87 | 929.3 | 2.27 | 0.54 | 3.72 | 501.5 | 6.20 |
| 1961-87 | 1,157.5 | 0.73 | 0.53 | 4.64 | 614.7 | 5.63 |
| Sugarcane | | | | | | |
| 1961-65 | 421.6 | -10.08 | 416.19 | 1,139.08 | 15,689.0 | -1.01 |
| 1966-71 | 403.6 | -31.75 | 409.81 | 979.33 | 14,228.8 | -36.51 |
| 1972-77 | 877.5 | 35.29 | 549.76 | 1,426.21 | 43,081.7 | 84.46 |
| 1978-82 | 946.6 | 16.43 | 472.53 | 1,187.82 | 41,249.7 | 37.65 |
| 1983-87 | 612.8 | -28.13 | 364.77 | 889.86 | 20,361.6 | -35.11 |
| 1961-87 | 651.5 | -2.87 | 445.37 | 1127.53 | 27,050.5 | 10.57 |
| Cotton | | | | | | |
| 1961-65 | 1,670.0 | 19.27 | 0.30 | 17.01 | 507.4 | 41.89 |
| 1966-71 | 2,215.1 | 30.29 | 0.35 | 18.18 | 771.3 | 54.21 |
| 1972-77 | 2,156.6 | 11.94 | 0.36 | 15.25 | 799.4 | 31.37 |
| 1978-82 | 2,217.9 | 9.38 | 0.36 | 12.93 | 800.8 | 23.61 |
| 1983-87 | 2,726.2 | 17.63 | 0.45 | 8.13 | 1,252.3 | 28.78 |
| 1961-87 | 2,196.3 | 17.46 | 0.36 | 13.96 | 823.2 | 34.37 |
| Vegetable oil | | | | | | |
| 1961-65 | 636.5 | 20.48 | 0.19 | 15.56 | 120.6 | 40.69 |
| 1966-71 | 691.9 | 27.24 | 0.22 | 11.56 | 151.0 | 41.80 |
| 1972-77 | 636.7 | 9.19 | 0.25 | 17.59 | 160.9 | 28.01 |
| 1978-82 | 668.6 | 33.31 | 0.30 | 28.51 | 200.7 | 71.78 |
| 1983-87 | 698.3 | 57.47 | 0.34 | 26.93 | 239.2 | 100.20 |
| 1961-87 | 666.3 | 27.33 | 0.26 | 20.46 | 173.1 | 55.63 |

*(continued)*

## Table 36—Continued

| Commodity/ Year | Area 2 | Change | Yield 2 | Change | Production 2 | Change |
|---|---|---|---|---|---|---|
| | (1,000 hectares) | (percent) | (metric tons/ hectare) | (percent) | (1,000 metric tons) | (percent) |
| Pulses | | | | | | |
| 1961-65 | 1,338.9 | -1.16 | 0.55 | 3.10 | 734.3 | 1.87 |
| 1966-71 | 1,243.0 | -0.58 | 0.51 | 2.18 | 630.0 | 1.73 |
| 1972-77 | 1,457.7 | -1.60 | 0.54 | 4.03 | 791.8 | 2.37 |
| 1978-82 | 1,401.5 | -4.60 | 0.43 | 2.98 | 602.4 | -1.99 |
| 1983-87 | 1,367.0 | -2.39 | 0.54 | 1.07 | 738.4 | -1.35 |
| 1961-87 | 1,360.8 | -2.05 | 0.51 | 2.69 | 700.2 | 0.69 |
| Fruits | | | | | | |
| 1961-65 | 114.1 | -0.42 | 8.53 | 1.23 | 975.2 | 1.09 |
| 1966-71 | 155.4 | 0.79 | 9.31 | 0.82 | 1,446.0 | 1.54 |
| 1972-77 | 193.7 | 6.75 | 10.15 | 5.03 | 1,971.8 | 12.32 |
| 1978-82 | 231.3 | -1.23 | 9.27 | 0.24 | 2,145.8 | -1.02 |
| 1983-87 | 320.2 | -5.71 | 9.00 | -1.65 | 2,875.9 | -7.32 |
| 1961-87 | 200.8 | -0.61 | 9.29 | 1.31 | 1,870.1 | 0.47 |
| Milk | | | | | | |
| 1961-65 | ... | ... | ... | ... | 7,028.8 | 5.77 |
| 1966-71 | ... | ... | ... | ... | 7,883.5 | 7.53 |
| 1972-77 | ... | ... | ... | ... | 9,127.6 | 12.21 |
| 1978-82 | ... | ... | ... | ... | 6,820.8 | -24.87 |
| 1983-87 | ... | ... | ... | ... | 8,124.7 | -25.40 |
| 1961-87 | ... | ... | ... | ... | 7,849.6 | -6.17 |
| Meat | | | | | | |
| 1961-65 | ... | ... | ... | ... | 407.8 | 2.02 |
| 1966-71 | ... | ... | ... | ... | 513.3 | 3.44 |
| 1972-77 | ... | ... | ... | ... | 717.8 | 12.42 |
| 1978-82 | ... | ... | ... | ... | 770.0 | -6.12 |
| 1983-87 | ... | ... | ... | ... | 1,011.8 | -6.53 |
| 1961-87 | ... | ... | ... | ... | 679.1 | 0.08 |

Sources: Model simulations and data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years); and Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years).

Notes: For wheat, maize, millet and sorghum, production and yield are expressed in terms of unmilled grain. For basmati and ordinary rice, production and yield are expressed in terms of millet rice (the conversion factor is 67 percent). For sugarcane, production and yield are expressed in terms of refined sugar. For cotton, production and yield are expressed in terms of lint cotton. For vegetable oil, area includes areas of rape and mustard, groundnuts, and sesamum seeds. Production and yield are expressed in terms of oil (using extraction rates of 34 percent for rape and mustard seed oil, 45 percent for groundnuts, and 40 percent for sesamum seed oil). For pulses, production and yield are expressed in terms of unmilled grains of grams and other pulses. For fruits, area, production, and yield include citrus fruits, mangoes, bananas, apples, guava, dates, apricots, peaches, pears, grapes, and pomegranates. For milk, production is expressed in terms of whole milk. For meat, production includes beef, mutton, and poultry. Change indicates percent change relative to historical levels.

## Table 37—Consumer prices, consumption, and trade (simulation 2)

| Commodity/ Year | Consumer Prices 2 | Change | Consumption 2 | Change | Trade 2 | Historical Trade |
|---|---|---|---|---|---|---|
| | (Rs/metric ton) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | |
| Wheat | | | | | | |
| 1961-65 | 699.2 | 59.8 | 4,441.1 | –5.4 | –89.6 | –959.2 |
| 1966-71 | 795.1 | 51.7 | 5,626.4 | –4.6 | 1,116.9 | –640.3 |
| 1972-77 | 2,085.3 | 134.9 | 7,229.2 | –11.5 | 4,445.5 | –1,051.2 |
| 1978-82 | 2,765.2 | 90.5 | 8,892.3 | –13.4 | 4,024.1 | –911.0 |
| 1983-87 | 3,188.7 | 57.7 | 10,688.2 | –12.2 | 3,371.0 | –805.2 |
| 1961-87 | 1,872.1 | 80.3 | 7,305.2 | –10.4 | 2,589.0 | –871.3 |
| Basmati rice | | | | | | |
| 1961-65 | 1,660.5 | 93.4 | 192.1 | –19.3 | 441.7 | 54.4 |
| 1966-71 | 2,062.9 | 97.6 | 248.3 | –17.1 | 1,063.6 | 117.3 |
| 1972-77 | 3,969.2 | 65.8 | 292.6 | 21.4 | 664.8 | 230.7 |
| 1978-82 | 5,935.6 | 33.1 | 512.5 | 4.3 | 712.8 | 293.0 |
| 1983-87 | 7,127.3 | 14.5 | 616.4 | –1.2 | 720.9 | 253.2 |
| 1961-87 | 4,067.0 | 40.2 | 364.8 | –1.6 | 731.4 | 188.5 |
| Ordinary rice | | | | | | |
| 1961-65 | 935.1 | 77.4 | 641.9 | –5.8 | 338.0 | 70.2 |
| 1966-71 | 1,258.3 | 107.7 | 1,035.2 | –10.7 | 1,047.6 | 20.8 |
| 1972-77 | 2,543.9 | 135.7 | 1,182.3 | –9.9 | 2,156.6 | 400.7 |
| 1978-82 | 3,337.7 | 81.4 | 1,229.3 | –9.1 | 2,275.5 | 742.1 |
| 1983-87 | 2,940.9 | 11.5 | 1,313.3 | 4.5 | 1,386.8 | 842.9 |
| 1961-87 | 2,180.8 | 67.6 | 1,082.5 | –6.6 | 1,452.8 | 400.2 |
| Maize | | | | | | |
| 1961-65 | 493.9 | 50.1 | 429.7 | –3.3 | 110.4 | 0.0 |
| 1966-71 | 648.7 | 59.8 | 550.2 | –6.7 | 341.0 | 0.0 |
| 1972-77 | 1,578.2 | 118.0 | 615.4 | –8.7 | 797.0 | 0.0 |
| 1978-82 | 1,632.2 | 24.1 | 822.5 | 4.0 | 200.5 | 0.0 |
| 1983-87 | 2,273.5 | 21.9 | 930.4 | 0.0 | 269.7 | 0.0 |
| 1961-87 | 1,309.6 | 45.4 | 663.2 | –2.7 | 360.4 | 0.0 |
| Millet and sorghum | | | | | | |
| 1961-65 | 446.9 | 11.9 | 611.4 | 7.6 | 0.0 | 0.0 |
| 1966-71 | 502.9 | 4.7 | 605.3 | 4.6 | 0.0 | 0.0 |
| 1972-77 | 999.6 | 7.7 | 575.2 | 3.7 | 0.0 | 0.0 |
| 1978-82 | 1,862.3 | 6.2 | 508.1 | 6.9 | 0.0 | 0.0 |
| 1983-87 | 2,817.3 | 6.6 | 451.5 | 6.2 | –0.1 | 0.0 |
| 1961-87 | 1,283.2 | 6.8 | 553.3 | 5.6 | 0.0 | 0.0 |
| Sugarcane | | | | | | |
| 1961-65 | 1,102.5 | –32.9 | 1,682.7 | 34.9 | –478.3 | –30.4 |
| 1966-71 | 904.9 | –48.4 | 2,533.3 | 47.4 | –1,461.9 | –37.7 |
| 1972-77 | 3,731.0 | 15.1 | 2,176.8 | 18.7 | 1,099.0 | –43.3 |
| 1978-82 | 4,054.5 | –22.2 | 3,005.3 | 21.9 | 322.5 | –34.6 |
| 1983-87 | 3,355.9 | –58.3 | 3,509.5 | 42.9 | –1,916.8 | –0.6 |
| 1961-87 | 2,606.7 | –32.6 | 2,564.8 | 32.8 | –464.5 | –30.1 |
| Cotton | | | | | | |
| 1961-65 | 4,495.4 | 98.4 | 146.8 | –26.6 | 309.9 | 121.8 |
| 1966-71 | 4,983.0 | 112.9 | 235.2 | –27.2 | 459.0 | 127.0 |
| 1972-77 | 10,629.8 | 72.7 | 458.0 | 9.7 | 261.4 | 130.0 |
| 1978-82 | 14,995.0 | 36.1 | 357.4 | –8.5 | 363.3 | 192.6 |
| 1983-87 | 16,050.7 | 15.2 | 443.4 | –9.8 | 683.7 | 383.8 |
| 1961-87 | 10,051.2 | 45.1 | 329.5 | –9.7 | 411.4 | 186.4 |
| Vegetable oil | | | | | | |
| 1961-65 | 3,151.0 | 90.3 | 115.9 | –25.2 | 26.1 | –54.2 |
| 1966-71 | 3,497.2 | 52.7 | 165.3 | –14.0 | 21.5 | –63.4 |
| 1972-77 | 7,562.9 | 4.5 | 425.8 | 28.7 | –228.2 | –177.5 |
| 1978-82 | 10,696.7 | 0.1 | 587.6 | 6.0 | –354.1 | –406.1 |
| 1983-87 | 13,020.7 | –0.6 | 821.6 | –3.6 | –523.7 | –680.4 |
| 1961-87 | 7,433.4 | 8.8 | 413.8 | 2.1 | –203.7 | –264.8 |

*(continued)*

## Table 37—Continued

| Commodity/ Year | Consumer Prices 2 | Change | Consumption 2 | Change | Trade 2 | Historical Trade |
|---|---|---|---|---|---|---|
| | (Rs/metric ton) | (percent) | (1,000 metric tons) | (percent) | (1,000 metric tons) | |
| Pulses | | | | | | |
| 1961-65 | 493.8 | 2.6 | 660.8 | 1.9 | ... | ... |
| 1966-71 | 709.8 | 1.2 | 567.0 | 1.7 | ... | ... |
| 1972-77 | 1,336.0 | 4.1 | 712.7 | 2.4 | ... | ... |
| 1978-82 | 3,936.7 | 3.9 | 542.2 | –2.0 | ... | ... |
| 1983-87 | 5,244.8 | –1.6 | 664.7 | –1.3 | ... | ... |
| 1961-87 | 2,246.4 | 1.2 | 630.2 | 0.7 | ... | ... |
| Fruits | | | | | | |
| 1961-65 | 937.6 | 7.3 | 877.7 | 1.1 | ... | ... |
| 1966-71 | 1,145.7 | 1.9 | 1,301.3 | 1.5 | ... | ... |
| 1972-77 | 2,658.1 | 27.3 | 1,774.6 | 12.3 | ... | ... |
| 1978-82 | 3,711.4 | –0.7 | 1,931.3 | –1.0 | ... | ... |
| 1983-87 | 4,411.5 | –14.3 | 2,588.9 | –7.3 | ... | ... |
| 1961-87 | 2,523.2 | 0.1 | 1,683.2 | 0.5 | ... | ... |
| Milk | | | | | | |
| 1961-65 | 692.9 | –2.1 | 6,326.0 | 4.9 | 0.0 | –53.0 |
| 1966-71 | 836.5 | –3.7 | 7,095.0 | 6.7 | 0.2 | –52.3 |
| 1972-77 | 1,571.8 | –21.1 | 9,824.9 | 33.3 | –1,610.0 | –51.0 |
| 1978-82 | 2,205.6 | –33.2 | 10,933.1 | 30.8 | –4,794.4 | –186.4 |
| 1983-87 | 3,411.8 | –32.3 | 11,877.9 | 18.8 | –4,565.7 | –198.5 |
| 1961-87 | 1,703.8 | –26.3 | 9,155.7 | 20.0 | –2,091.1 | –104.1 |
| Meat | | | | | | |
| 1961-65 | 1,062.3 | –7.4 | 367.0 | 2.0 | ... | ... |
| 1966-71 | 1,496.2 | –6.4 | 462.0 | 3.4 | ... | ... |
| 1972-77 | 3,350.7 | –8.4 | 646.0 | 12.4 | ... | ... |
| 1978-82 | 6,965.5 | –4.0 | 693.0 | –6.1 | ... | ... |
| 1983-87 | 9,957.8 | –7.6 | 910.6 | –6.5 | ... | ... |
| 1961-87 | 4,407.7 | –6.6 | 611.1 | 0.1 | ... | ... |

Sources: Model simulations and data from Pakistan, Ministry of Finance, *Economic Survey* (Islamabad: Ministry of Finance, various years); and Pakistan, Ministry of Food, Agriculture and Co-operatives, *Agricultural Statistics of Pakistan* (Islamabad: Ministry of Food, Agriculture and Co-operatives, various years).

Notes: For wheat and maize, trade is expressed in terms of unmilled grain. For basmati and ordinary rice, trade is expressed in terms of milled rice. For sugarcane, trade is expressed in terms of refined sugar. For cotton, trade is expressed in terms of lint cotton. For vegetable oil, trade includes soybean oil, palm oil, and cotton oil. For milk, trade is expressed in terms of whole milk (dry milk is converted, using a quality factor of 90 percent and a conversion ratio of 1:8). Milk was not traded prior to 1971. Millet and sorghum, fruits, meat, and pulses are nontradables. Change indicates percent change relative to historical levels.

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# COMMERCIALIZATION OF AGRICULTURE UNDER POPULATION PRESSURE: EFFECTS ON PRODUCTION, CONSUMPTION, AND NUTRITION IN RWANDA

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# COMMERCIALIZATION OF AGRICULTURE UNDER POPULATION PRESSURE: EFFECTS ON PRODUCTION, CONSUMPTION, AND NUTRITION IN RWANDA

**Joachim von Braun**
**Hartwig de Haen**
**Juergen Blanken**

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# FOREWORD

Rapid population growth in agroecologies that are already under high population pressure poses a major challenge for development policy. It becomes an even greater challenge in complex agroecologies where little new technology for rapid agricultural expansion is available. The mountain zones of the Zaire-Nile Divide in Central Africa present an example of such a challenging environment where agriculture has encroached onto marginal zones, that is, water catchment areas and the last tropical forests of the area. This study by von Braun, de Haen, and Blanken highlights the potentials of agricultural development for the employment, income, and consumption of the poor, but also stresses that nonagricultural rural growth and employment expansion are key to improved food security and nutrition in this setting. The authors show that the delivery of public goods—health services, sanitation, and education—has to move ahead in order to maintain and improve the human capital foundation in this stressed environment.

The study is based on detailed primary household data utilized in innovative ways to assess the household's and farmer's (and her husband's) behavior in the subsistence economy vis-à-vis options for specialization. A number of interesting policy findings emerge, such as the poor being too poor to capture the gains from efficient specialization because they need to take care of subsistence-based insurance against hunger.

While generally favorable effects of commercialization of agriculture for nutrition are manifested by this study and preceding IFPRI studies on this topic, the present study also draws attention to the need for concern about land tenure when the stimulus for agricultural commercialization is given in a land-scarce environment.

Just Faaland

Washington, D.C.
January 1991

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Much of the extensive fieldwork for this study in Rwanda was supervised by Joanne Csete, who also contributed to the design and field-testing of questionnaires for the complex survey, especially in the areas of consumption and nutrition.

The large data sets were handled in a most efficient way by Graciela Wiegand-Jahn, who also contributed greatly to the analysis and interpretation of results.

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# 1

# SUMMARY

Increased market integration of traditional agriculture is part of a development strategy oriented toward growth. Integration in the local, national, and international exchange economies promises gains through specialization. But it is the design of programs and policies and their actual implementation that determine whether or not the poor obtain a fair, or even a positive, share of gains from agricultural commercialization, directly or indirectly. Gains for the poor are not a priori assured, and numerous cases quoted in the literature—though not well documented and frequently methodologically flawed—point to adverse effects of increased market integration on the welfare of the poor, including their nutrition.

This study, which is part of a larger effort at IFPRI, looks in detail into the effects of commercialization on production, income, employment, consumption, and nutrition. The study location is in Rwanda and is among Sub-Saharan Africa's most densely populated rural areas.

The specific objectives of this research are, first, to assess the effects of the interaction between increased commercialization and population growth on production, household real incomes, family food consumption, expenditures for nonfood goods and services, and the nutritional status of the population, and second, to develop a long-term perspective, based on household analysis, of the implications of this change for agricultural, infrastructural, employment, and nutrition policies.

The empirical analysis of the research is based upon a detailed survey of production, income and consumption, nutrition of individuals, and health in about 200 households. The survey was undertaken during 1985/86 in an area in the high-altitude zone of the Zaire-Nile Divide in northwestern Rwanda. The study area is very densely populated, and a high population growth rate (4.2 percent) increases the pressure. The study site also is undergoing agricultural commercialization induced especially by the introduction of tea production and the expansion of potato production for the market. While tea and potatoes play important roles in the overall commercialization of rural households via product and labor markets, other important forces identified by the survey are nonagricultural off-farm employment and home production activities, the latter especially referring to the brewing of sorghum beer as a more traditional form of commercialization.

The economic analysis of tea production in the study area concludes that the crop is not adding to aggregate income there, because competition with other crops (cereals, pulses, roots, and tubers) is strong, and established tea factory capacities are underutilized, leading to high fixed costs per unit of output. One parastatal tea factory in the study area responded to these efficiency problems by externalizing costs: smallholders were expropriated and land was added to the factory-managed plantation to reach higher-capacity utilization. Such an aberration of commercialization and the finding of lack of comparative advantage of tea are departures from the generally successful introduction of tea into Rwanda's economy.

Commercial potato production in the area is done in a former natural forest area (Gishwati forest), partly on licensed plots obtained from a reforestation project on a temporary basis and partly in an uncontrolled form without such entitlements. This potato production is concentrated in larger holdings—that is, in the context of this smallholder system, on farms with more than 1.5 hectares. The average farm size in the sample is 0.7 hectare per household. While central to current employment and household food availability, potato production in the forest area—a key water-catchment area—poses risks to sustainability of the production environment in the longer run.

Agriculture in the study area is still very subsistence-oriented. On average, 67.5 percent of the value of agricultural production is consumed by the households, thus aggregate marketed surplus is 32.5 percent. Sorghum beer and potatoes account for about 30 percent each of agricultural sales, and the remaining 40 percent is from livestock, tobacco, tea, and occasional sales of subsistence crops such as sweet potatoes and sorghum.

Yet a look at agriculture alone would give a biased impression of overall rural commercialization. The great majority of farm households have sizable nonagricultural incomes. Off-farm income is on average 57.5 percent of total income, and in the smallest farm-size quartile it reaches 80.1 percent. Off-farm employment is largely found by men, while women do most of the fieldwork. Women account for 74.1 percent of family labor input in agriculture. Only in single-crop potato production with modern inputs do men contribute an important share of labor input. A significant share of the work force on the tea plantations—mainly for plucking—consists of women (19 percent in 1985). So far, this is the only significant off-farm employment of women in the area.

Subsistence orientation—that is, the share of own-produced food in total per capita food and nonfood consumption—is remarkably stable across different farm sizes and per capita income levels. The value of own-produced food in percentage of the total value of food and nonfood consumption is on average 47.8 percent. Multivariate analysis shows that, all else holding constant, this value shrinks by only 1.3 percent with a 10.0 percent increase in land scarcity (person-land ratio).

Although options for gains from commercialization and specialization appear to exist, the poor farmers in this setting forgo them to a large extent because of the need for food insurance (subsistence). They are thus too poor to opt for an "efficient" production pattern. Yet from their household perspective, efficient resource utilization—including that for food insurance—needs to be factored in.

The critical development issues in this very densely populated region relate to employment and labor productivity. Gross margins per labor day for major crops in 1985/86 ranged between US$0.44 for sorghum in mixed cultivation and US$0.71 for sweet potatoes and were about US$0.60-0.70 for potatoes and maize. Econometric estimates point to the interesting finding that increased land scarcity in the study area, due to the rapid population growth (4.2 percent a year in the 1980s), can still be substantially compensated for by intensification of labor and capital input per unit of land. The indigenous mechanisms for increasing labor productivity under increased land scarcity are found to be sizable: a 10 percent increase in the person-land ratio results in only a 3.6 percent decline in labor productivity. While this is encouraging, given the already extremely high person-land ratio in the area (5.5 adult-equivalent persons per hectare), it also stresses the increased need for technological change.

The major proportion of incremental income that households earn is spent on food. For an average household a 10 percent increase in income leads also to a 10 percent increase in the consumption value of food, and to an increase of 5 percent in calorie consumption. Richer households spend much more for a more diverse diet. Consequently, households in the top per capita income quartile spend 77 percent more per calorie than households in the poorest income quartile.

Hunger, that is, calorie deficiency, is a problem in a large proportion of households. Calorie consumption has only a weak link to farm size but a strong one to income. In mid-1986, 41 percent of the households consumed less than 80 percent of recommended requirement levels—a commonly used critical cutoff point below which calorie consumption levels are seriously deficient. Among the calorie-deficit households is a large share of those who were continuously in deficit over the survey period (about 60 percent of the deficit households). In these households in particular, the nutritional status of children deteriorates, and increased growth retardation and underweight are in fact diagnosed for the children. In the total sample population in 1986, 21.5 percent of all children below 7 years of age are identified as stunted (below 90 percent of the height-for-age standard), and 12.3 percent are substantially underweight (below 80 percent of the weight-for-age standard). Scarcity of subsistence food, cash, and time impinges on the nutritional outcome. Time constraints of adults—that is, women in the most resource-poor households—lead to a shift of labor demand to children for the production of home goods, such as fuelwood collection and water fetching. Children fulfill these tasks to a much larger extent in calorie-deficient households than in others.

Increasing household calorie consumption is important but alone does not solve the nutritional status problem. The effects of the health environment and household sanitation on children's anthropometric status are very substantial. Doubling household calorie consumption from 1,500 to 3,000 calories per adult-equivalent—an extreme change indeed—would reduce stunting by about a quarter of a standard deviation (or 17 percent of the Z-score mean), whereas a worm cure would have the same effect, and a clean latrine would have twice this impact on nutritional status. This underlines the role of improved health services, accessible to the poor, in nutritional improvement. Richer households spend substantially more on health care than the poor (calorie-deficient households) can afford.

Long-term simulations with a demographic model stress the important role of the area's rapid population growth in the rural transformation process during the next two decades. The rapidly rising person-land ratio is expected to further increase intensification of food crop production with higher labor inputs per unit of land. A substantial absolute and relative expansion of sweet potato production stands out as a result and points to the importance of an increased focus on technological change in this crop.

In a rapidly increasing share of rural households, self-sufficiency in staple foods will drop very fast within the coming decade. The person-land ratio in the area will increase from 5.5 adult-equivalent persons per hectare in 1985 to 12.0 per hectare in 2005. Most dramatic is the labor-supply expansion for nonagricultural employment that will, even under cautious assumptions in the simulations, more than double from its already high level.

# 2

# RESEARCH OBJECTIVES

Commercialization of the rural sector is considered a cornerstone of successful economic development. It allows increased participation of individuals and households in the domestic and international exchange economy. Through realization of comparative advantages, it is supposed to benefit not only individual rural families but also the agricultural sector and the whole economy.

Commercialization may have many facets in this context. Generally speaking, it describes an individual's or a household's economic transactions with others. These may be both in cash and in kind, the latter playing a considerable role in many traditional communities. Transactions may relate to agricultural produce, indicating that a certain proportion of a farm's output is not produced for subsistence but for sale. They may also relate to inputs, indicating that a farm's production technology depends to a certain extent on external inputs. Finally, a household may also be commercialized by earning off-farm income, mostly from labor employment outside the household, but possibly also from capital investment.

Evidently, all these transactions will not only enable a rise in a family's or an individual's income; they may also improve the nutritional situation, provided there is a preference for better nutrition and provided the individuals are able to express these preferences and get access to increased food supplies. While the first condition—high preference for food—will be mostly fulfilled, the latter—realization of preferences and market access—may not in cases of market failure or policy failure. In fact, a survey of research findings concerning the effect of commercialization in agriculture on the alleviation of poverty, on the distribution of food, and on the nutritional status of vulnerable groups has shown mixed results (von Braun and Kennedy 1986).

Insufficient food consumption to meet nutritional requirements is closely related to poverty, and a significant portion of increasing incomes among the poor would be expected to be spent on more food. If low-income farmers and landless laborers capture at least part of the economic surplus generated by shifts from subsistence to cash crop production, and if a portion of these people are malnourished, one would expect that the nutritional status would improve. Conceptually, these relationships are, however, not straightforward, and a review of the literature showed that results from past studies do not provide satisfactory answers (von Braun and Kennedy 1986). As will be shown below, complex farm and rural household production-consumption relationships need to be understood and quantified in order to address these relationships properly for policy conclusions.[1]

This research has two objectives. First, to assess the effects of increased commercialization on production, household real incomes, family food consumption, expenditures for nonfood goods and services, and the nutritional status of the population in an environment under severe population pressure. Second, to describe the process by which household food consumption and nutritional status are affected by increased commercialization, identifying the most important elements of the process and estimating how each element is influenced by the change. The analysis should form a basis for evaluating the alternative short- and long-term options for the design of policies and programs to cope with possible income and nutrition problems in the process of transformation from semisubsistence to more commercialized agriculture.

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[1] Studies into the issue by Kennedy and Cogill (1987) in Kenya, von Braun, Puetz, and Webb (1989) in The Gambia, and von Braun, Hotchkiss, and Immink (1989) in Guatemala show generally positive net effects of commercialization for nutrition, or at least no adverse effects.

This study—undertaken in a very densely populated location in northwestern Rwanda—forms part of a larger research effort at IFPRI on the policy questions posed by the commercialization process in traditional agriculture. While an integrative study of several studies is also currently being undertaken for more generalizable conclusions, each of the studies offers in-depth insight into the causes and consequences of commercialization in different socioeconomic and ecological environments. This study is located in an area that is unusual on a number of counts—it has an extremely high population density, an extremely high population growth, and an extremely low degree of urbanization, and is extremely landlocked in the center of Africa. The authors argue that it is particularly revealing to study such an "extreme" case in order to derive insights for future policy directions. In this case, this argument applies especially to the changes induced by the high level of rural population density and its rapid growth.

There is an urgent need to improve the understanding of the development process in densely populated areas under increased population pressure, such as the study region, where there is little new agricultural production technology. Also, the interaction between agriculture and the rest of the rural economy especially requires further research. It can be hypothesized that a higher population density makes possible more rapid attainment of gains from specialization and the emergence of a rural service sector. Moreover, high population density may limit the number of households able to survive from agriculture alone, thus forcing some into nonfarm activities to supplement income (Haggblade and Hazell 1987).

A central research issue for this study location under population pressure is the sustainability of agricultural production systems along with the efficient use of the resource base. A long-term view of options and alternatives is required for this issue (Tisdell 1988). Much effort has been made to develop sustainable agricultural production systems in Rwanda (Kotschi, Pfeiffer, and Grosser 1982), yet their attractiveness to small farmers has remained rather limited. To understand and overcome adoption problems, experimental work in the field of sustainable systems should start at the farm level and include assessment of short- versus long-run costs and benefits to farmers and the economy (Adelhelm and Kotschi 1985). While the present study acknowledges this critical requirement, it adds the dimensions of household production-consumption relationships and farm-nonfarm sector links, which are of central importance to agricultural technology adoption in subsistence farming.

# 3

# THE FORCES DRIVING THE COMMERCIALIZATION PROCESS

## Underlying Structures and Policies

Rwanda is among the most densely populated countries in the world, and its population density expressed in terms of inhabitants per square kilometer is very high (about 246 persons per square kilometer in 1987). The country is landlocked in the center of Africa, with long road transport routes across neighboring Burundi and Tanzania or Uganda and Kenya to the nearest seaports—Mombasa, Tanga, or Dar es Salaam. The related high transportation costs are almost prohibitive for the integration of bulky commodities into the international exchange economy. For instance, transport costs for cereals from Rwanda to seaports (for example, Mombasa) exceed normal f.o.b. world market prices. Thus, export and import parity prices of cereals in Rwanda establish a range between negative and more than twice the long-term average of the c.i.f. East Africa coast price.

Failure of the domestic market to get access to international food markets is a reality for this landlocked country, as crises in neighboring countries occasionally block the trade routes. Consequently, Rwandan food policy emphasizes high national self-sufficiency and increasing regional market integration (Rwanda, Ministry of Planning 1983).

The Rwandan economy is only weakly integrated into the international exchange economy. The value of merchandise exports represents only 8 percent of gross domestic product (GDP). For a landlocked country, an extremely low proportion of exports goes to neighboring regions: 81 percent of all exports found their way to the industrial market economies in 1985 (Table 1) (Sinamenye 1986). The economy as a whole appears to be quite subsistence-oriented, which is further suggested by the extremely low degree of urbanization (only 5 percent of the population lives in urban centers). The share of agriculture in GDP, however, was substantially reduced during 1965-85, from 75 percent to 45 percent. This change in the share of agriculture clearly indicates a substantial increase in internal diversification and specialization, including rural nonagricultural activities.

In comparison with other African countries, Rwanda has not incurred very high debts and was therefore not much affected by the debt crisis of the 1980s. Debt service in percentage of total exports stood at only 4.3 percent in 1985, a low burden for the economy. In income per capita (gross national product [GNP]), Rwanda ranks among the 25 poorest developing countries. Life expectancy at birth is even below the average found in low-income economies (for selected indicators, see Table 1).

So far, Rwanda's integration into the international exchange economy has been largely based on agricultural exports, specifically coffee and, more recently, tea. In 1985, coffee composed 65 percent and tea 15 percent of total exports from Rwanda. Yet export crops and nonfood cash crops cover only a minor share—5.6 percent in 1983—of total arable land in the country. At the aggregate, food availability per capita appears to have

## Table 1—Some basic features and long-term trends of Rwanda's economy, 1965-85

| Item | 1965 | 1985 | 1965-85 Average |
|---|---|---|---|
| Population (millions) | 3.2 | 6.1 | ... |
| Population growth (percent/year) | ... | ... | 3.1 |
| Urban population (percent) | 3.0 | 5.0 | ... |
| Gross national product (US$/capita, in 1985 dollars) | 195 | 280 | ... |
| Growth of GNP per capita (percent/year) | ... | ... | 1.8 |
| Share of agriculture in GDP (percent) | 75.0 | 45.0 | ... |
| Exports (merchandise) (percent of GDP) | n.a. | 7.6 | ... |
| Share of total exports to industrial market economies (percent) | 96.0 | 81.0 | ... |
| Debt service (percent of exports) | n.a. | 4.3 | ... |
| Share of coffee and tea in total exports (percent) | n.a. | 79.8 | ... |
| Official development assistance (percent of GNP) | n.a. | 10.7 | ... |
| Calorie supply (per capita/day) | 1,665 | 1,919 | ... |
| Infant mortality rate (per 1,000 children below 1 year) | 141 | 127 | ... |
| Life expectancy at birth (years) | n.a. | 48 | |

Sources: African Development Bank, *Selected Statistics on Regional Member Countries* (Abidjan: ADB, 1987); World Bank, *World Development Report* (Washington, D.C.: World Bank, 1987); International Monetary Fund, *International Financial Statistics* (Washington, D.C.: IMF, 1987).

Note: n.a. means not available.

increased over recent decades.[2] This growth was largely a result of the expansion of land area into marginal zones (Delepierre 1985). The population density in terms of persons per hectare of cropland has increased by 30 percent since the early 1960s and stood at more than eight persons per hectare in the mid-1980s (Table 2).

With a population growth of 3.3 percent a year in the 1980s, the already very limited land base becomes more and more a constraint to agricultural growth and income generation. The obvious way out of this dilemma appears to be a combination of policies that will lead to reduced population growth, increased land productivity through technological change in agriculture, conversion of land resources, and increased exploitation of the potentials of specialization in the rural economy. Investments in rural infrastructure, education, and technological change in agriculture should be the key inputs. Providing improved understanding of the potentials and the constraints in fostering this process is a main task of this research.

The diversity of the country and of the region cannot be captured by a case study for just one location. However, the microlevel processes of commercialization studied at the

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[2] It should be noted that such assessments are made on the basis of rather weak food production and trade statistics (African Development Bank 1987; World Bank 1987; International Monetary Fund 1987).

Table 2—Total arable land area, land use for export crops, and population density in Rwanda, 1961-83

| Item | 1961 | 1973 | 1983 |
|---|---|---|---|
| Arable land (1,000 hectares) | 521 | 610 | 750 |
| Export crops and nonfood cash crops (percent of arable land) | 4.6 | 5.1 | 5.6 |
| Population density (persons/hectare of arable land) | 6.2 | 6.5 | 8.1 |

Sources: Computed from FAO Production Yearbooks and African Development Bank statistics.

location may be generalized under certain conditions. These processes and the responses of the households to them are the main interests of this study.

## The Study Area

The research for the present study was conducted in the *commune* of Giciye, which is situated in the *préfecture* (district) of Gisenyi in the northwestern part of Rwanda (Figure 1). Some survey work also was done in the neighboring *commune*, Karago. The following description focuses on the main study area in Giciye *commune*.[3]

The total area of Giciye *commune* is estimated at 185 square kilometers, approximately 120 square kilometers of which are suitable for agricultural production, the remainder being part of the former natural forest of Gishwati.

Before the *communes* are described in more detail, some explanation should be given to better understand what a *commune* is in Rwanda. Since the administrative reform of 1974, a *commune* can be regarded as the lowest governmental and administrative unit, with a *bourgmestre* as the official government representative. The *bourgmestres* are nominated by the country's president. The *commune* is further subdivided into *secteurs*, which again are subdivided into *cellules*. A *cellule* normally consists of some 100 families.

### Agroecological Zone Characteristics

Following the classification of Rwanda into the agroecological zones given by Gotanègre, Sirven, and Prioul (1974) and Jones and Egli (1984), the study area belongs to the agroecological zone of the Central Zaire-Nile Divide that passes through Rwanda from north to south, with the agroecological zones of the Kivu Lakeshore to the west and the High Plateaus to the east. The main characteristics of the Central Zaire-Nile Divide are relatively high altitudes, normally exceeding 2,000 meters, low average annual temperature of approximately 15°C, and abundant precipitation averaging 1,300 millimeters a year (Jones and Egli 1984). In the study area, altitude increases rapidly from 1,500 meters in the east, at the border of the High Plateaus region, to approximately 3,000 meters at the summit of the Gishwati forest, with most of the communal area situated at more than 2,000 meters.

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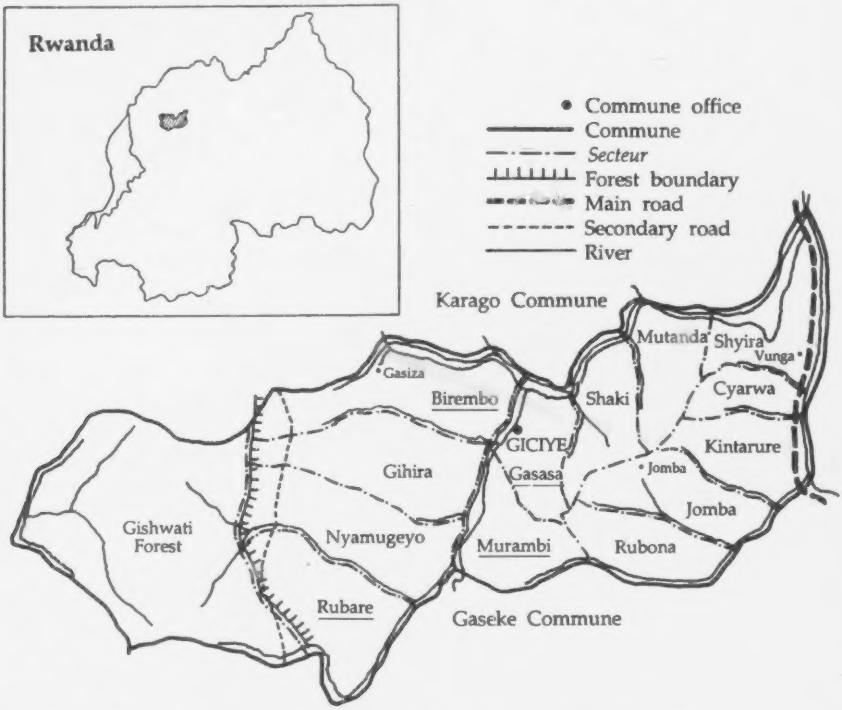
[3] The following description of the study area is mainly based on the 1984 annual report of Giciye *commune*.

**Figure 1—Map of the study area**



Note: The underlined *secteur* names are those of the four *secteurs* selected for the study.

During 1983-85, annual precipitation averaged 1,236 millimeters, which is rather low because 1984 was a drought year with rainfall of only 948 millimeters or 68 percent of the amount in normal years (1,380 millimeters). However, because of the prevailing temperature and moisture regimes, the risk of crop failure due to changing climatic conditions may be considered generally low. Since this is an equatorial region, the distribution of rainfall follows a bimodal pattern. Four climatic seasons can be distinguished: a long rainy season from mid-February to late May; a long dry season from the end of May to mid-September; a short rainy season from mid-September to early or mid-December; and a short dry season until mid-February.

Another important characteristic of this agroecological zone is its mountainous relief dominated by very steep slopes of up to 30°-40°, causing severe surface soil erosion. In fact, soil erosion due to the deforestation and transformation of former forest and pastureland into permanent arable farmland will be one of the most important problems of future development of farming systems in the study area.

Soils are generally very poor and acid, mainly derived from metamorphic rocks like granites, schists, and gneisses. The analysis of a soil sample of 90 farm plots undertaken for this study revealed a high degree of soil acidity and a general deficit of phosphorus. In some higher-altitude areas of the *commune*, soils are found to be aluminum toxic, thus prohibiting normal crop production, with the exception of tea, which can stand this level of aluminum concentration.

The output mix of farms in the various agroecological zones shows a high degree of variety—a major problem for setting commodity priorities for agricultural innovations. This is exemplified in Table 3, which shows the crop production per farm in the two *préfectures*, Ruhengeri and Gisenyi, each broken down by agroecological zone. The differences in importance of bananas, potatoes, and coarse grains for the various agroecological zones are particularly pronounced.

### Population

According to the population census, the total population of Giciye *commune* was 52,236 at the end of 1984. The average annual increase between 1978 and 1984 was 4.2 percent. The composition by age groups reveals a high population share (46.2 percent) for the group below 18 years of age and only 5.2 percent for that above 60 years of age.

In 1984 the composition by ethnic groups in the *commune* was Hutu (98.8 percent) and Tutsi (1.0 percent), the remainder being Twa, the pygmy aborigines. Average population density was 282 persons per square kilometer in 1984, or 435 persons when only the area suitable for agricultural production is taken into account. However, population density varies considerably among the different administrative sectors of the *commune*, from approximately 270 persons per square kilometer in some higher-altitude *secteurs* in the west to more than 900 persons per square kilometer on the volcanic soils at the border of the High Plateaus in the east.

### Markets and Social Infrastructure

There is only one main road (*route principale*) that crosses the communal area of Giciye (Figure 1). This road descends for a distance of 24 kilometers from Giciye to Mukamira, an important marketplace situated at the paved road that links the provincial capitals of Gisenyi and Ruhengeri to the capital, Kigali.

The area is equipped with two health centers in the Karago *commune*, and one in Giciye attached to a hospital. Another hospital is located in the neighboring Kabaya *commune*.

In Giciye, there are 19 primary schools spread throughout the *commune* area. In Karago, there are 14 primary schools and 2 secondary schools.

In both *communes*, there is a *centre communal de développement et de formation permanente* (CCDFP), with branch centers for some *secteurs*. The main activities of the CCDFP are in the fields of literacy campaigns, improvement of agricultural practices, hygiene, and family planning. The centers work in close collaboration with the local cooperatives.

Giciye *commune* has three markets of different size and importance: a market takes place twice a week in Gasiza, Jomba, and Vunga (Figure 1). Kabaya is another important marketplace situated at the border of Giciye and Gaseke *communes* in the south of the study area.

Using the typology of Rwandan agricultural markets developed by the national agricultural research organization (*l'Institut des Sciences Agronomiques du Rwanda* [ISAR]), Jomba and Gasiza may be classified as *marchés paysans*—that is, relatively small rural markets of only local importance—where farmers themselves constitute the majority of sellers and buyers. The number of merchants and middlemen organizing the

### Table 3—Product mix in different agroecological zones in and around the study area, 1984

| *Prefecture/* Zone | Altitude | Farm Size | Persons per Household | Annual Production per Farm |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Beans | Peas | Potatoes | Sweet Potatoes | Sorghum | Maize | Bananas |
|  | (meters) | (hectares) |  |  |  |  | (kilograms) |  |  |  |
| Ruhengeri |  |  |  |  |  |  |  |  |  |  |
| Lava earth | 2,000 | 0.87 | 5.2 | 214 | 39 | 1,493 | 157 | 394 | 401 | 564 |
| Zaire-Nile Highlands[a] | 1,950 | 0.87 | 5.3 | 191 | 74 | 108 | 476 | 44 | 49 | 1,385 |
| Buberuka Highlands | 1,950 | 1.13 | 5.6 | 386 | 132 | 143 | 841 | 275 | 226 | 1,404 |
| Central Plateau | 1,837 | 0.87 | 4.9 | 219 | 14 | 4 | 794 | 17 | 63 | 2,327 |
| Gisenyi |  |  |  |  |  |  |  |  |  |  |
| Lake Kivu border | 1,733 | 0.85 | 6.3 | 272 | 2 | 0 | 280 | 13 | 28 | 2,657 |
| Zaire-Nile Highlands[a] | 2,356 | 1.33 | 3.9 | 71 | 119 | 676 | 626 | 179 | 424 | 112 |
| Central Plateau | 1,750 | 0.57 | 6.2 | 125 | 3 | 0 | 501 | 0 | 20 | 915 |

Source: Rwanda, Ministry of Agriculture, Animal Husbandry, and Forestry (computed from primary farm data, Enquête Nationale Agricole), Kigali, 1985.

[a] The data for the Zaire-Nile Highlands zone (above 2,000 meters) are most comparable to the survey done specifically for this study in Giciye *commune*. It should be noted that the data from Ruhengeri *prefecture* in this zone include some farms below 2,000 meters that are already in the banana-growing zone.

interregional exchange of agricultural products of different agroecological zones is limited to a very few in this type of market.

On the other hand, Kabaya and, in particular, Vunga can be classified as *marchés collecteurs,* markets of medium to high importance in the interregional exchange of agricultural produce. Vunga, in the eastern part of the study area, is one of the most important markets of the whole northern region of Rwanda; 75 percent of the total number of traders registered in Giciye *commune* are found in Vunga.

## Sources of Rural Commercialization

The commercialization process in the study area reveals itself in the changing income sources of households and changing patterns of employment in the rural communities. The commercialization process occurs partly on the basis of indigenous sources of nonagricultural employment, cash crops, and manufacturing activities. Processing of beer from sorghum is the main commercialization activity of the indigenous type. Among the new sources of commercialization, the production of tea and the expansion of potato production have the primary positions. Finally, increased off-farm employment generated by project activities in the community has acquired increased importance. Before these sources of commercialization are traced in detail at the household level, background information at the regional and community levels is provided in the following sections. Special attention is paid to the role of tea because of its importance in the national context.

### Expansion of Tea Production

*Tea Production in the National Context.* In Rwanda the introduction of tea goes back to the early 1950s when some private settlers started tea production more or less on an experimental basis. In 1957, the acreage under tea was estimated at approximately 200 hectares, and the crop was further processed in neighboring factories of Uganda and Zaire. The construction of the first Rwandan tea factory in Mulindi began in 1960. However, it was not until independence in 1962 that tea production started to expand on a larger scale, following two feasibility studies financed and partly carried out by the European Development Fund in 1961/62.

The main rationale in giving priority to tea production was seen in a diversification of agricultural production, export crop production in particular, because the Rwandan economy depended almost entirely on the export of coffee. Expansion of rural employment for the rapidly growing population was another motive for the promotion of tea production. The very promising performance of tea production in neighboring countries, particularly in Kenya, further encouraged the introduction of tea (Lamb and Muller 1982).

The rapid expansion of the acreage under tea during the early stages was not detrimental to food crop production. The establishment of tea production schemes took place mainly by clearing and planting former forest land in the high-altitude regions of the Central Zaire-Nile Divide and by draining and cultivating large, formerly uncultivated swamps in lower-altitude areas. The total acreage devoted to tea grew from approximately 285 hectares in 1962 to 10,120 hectares in 1984 (Table 4). Still, in 1984, tea acreage represented only 0.8 percent of total arable land.

Table 4—Total and harvested tea areas, production of dry tea, and yields of dry tea per hectare in Rwanda, 1962-85

| Year | Total Area | Harvested Area | Production of DryTea | Yield of Dry Tea |
|---|---|---|---|---|
| | (hectares) | | (metric tons) | (kilograms/ hectare) |
| 1962 | 285 | n.a. | n.a. | n.a. |
| 1967 | 1,000 | 799 | 518 | 648 |
| 1971 | 3,087 | 2,144 | 1,819 | 848 |
| 1975 | 5,496 | 3,459 | 3,995 | 1,155 |
| 1978 | 7,537 | 5,915 | 4,859 | 821 |
| 1979 | 8,393 | 6,635 | 5,230 | 788 |
| 1980 | 8,876 | 7,315 | 5,910 | 808 |
| 1981 | 9,221 | 7,470 | 6,845 | 916 |
| 1982 | 9,506 | 7,392 | 7,050 | 954 |
| 1983 | 10,449 | 7,991 | 7,584 | 950 |
| 1984 | 10,120 | 8,229 | 8,708 | 1,058 |
| 1985 | 9,970 | 8,826 | 11,332 | 1,284 |

Source: Annual reports of *l'Office des cultures industrielles du Rwanda-thé* (OCIR-Thé), Rwanda.
Note: n.a. means not available.

The production of dry tea grew from 518 metric tons[4] in 1967 to 8,708 tons in 1984, or by 18.1 percent annually. The total value of tea exports in current prices increased from approximately FRw 190 million in 1972 to FRw 1,587 million in 1985, thus contributing approximately 12-13 percent of the total value of all exports since 1977 and lessening significantly the heavy dependence of the Rwandan economy on coffee exports.

*Tea in the Study Area.* In the study area, initiation of tea production started in the mid-1970s with the establishment of the factories at Rubaya in 1975 and Nyabihu in 1976. However, it was not until 1980/81 that the factories were completed and the production of dry tea began. The Rubaya factory is located close to the Gishwati forest in Gaseke *commune* at the southwestern border of Giciye *commune*. The factory's processing capacity is 1,200 tons of dry tea per year. Tea production is based on both plantation and smallholder schemes. Table 5 reveals that in Rubaya, smallholder tea accounted for approximately 70 percent of the total harvested area but for only 48 percent of total production in 1985. The harvested area under smallholder tea has been unstable in the past and has declined since 1981. While smallholder yields in kilograms of dry tea per hectare and year are far below the Rwandan average for this category, the respective yields for plantation tea are exceptionally high and above the Rwandan average. Given the large share of smallholder tea in the total harvested area and the extremely low productivity of the smallholders, the rate of utilization of the processing capacity was only 38 percent in 1985.

It should be emphasized that the establishment of Rubaya plantation took place mainly by clearing and planting formerly uncultivated parts of the Gishwati forest and that it was not detrimental to food crop production, except for some 38 hectares of expropriated farmland with a total of 43 families that have been compensated. They were able to resettle nearby.

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[4] All tons in this report are metric tons. Dry tea is the manufactured product when it leaves the factory.

Table 5—Harvested area and production of plantation and smallholder tea for Rubaya and Nyabihu factories, 1980-85

| Factory | 1980 | 1985 |
|---|---|---|
| Rubaya | | |
| Plantation tea | | |
| Harvested area (hectares) | 84 | 150 |
| Production of dry tea (metric tons) | 62.4 | 241.5 |
| Yield of dry tea (kilograms/hectare) | 743 | 1,610 |
| Smallholder tea | | |
| Harvested area (hectares) | 332 | 342 |
| Production of dry tea (metric tons) | 39.4 | 220.2 |
| Yield of dry tea (kilograms/hectare) | 119 | 644 |
| Nyabihu | | |
| Plantation tea | | |
| Harvested area (hectares) | 150 | 416 |
| Production of dry tea (metric tons) | 47.4 | 332.1 |
| Yield of dry tea (kilograms/hectare) | 316 | 798 |
| Smallholder tea | | |
| Harvested area (hectares) | 18 | 30 |
| Production of dry tea (metric tons) | 2.1 | 24.2 |
| Yield of dry tea (kilograms/hectare) | 117 | 807 |

Source: Records of tea factories in Rubaya and Nyabihu.

The Rubaya factory maintained some 180 hectares of eucalyptus forest in the Gishwati area in 1985 to provide its own firewood for tea processing. The plantation currently extends into the Gishwati area, and the objective is to have 600 hectares of tea plantation and another 250 hectares of forest by the year 1990.

The Nyabihu factory is situated in Karago *commune* and has a capacity of 800 tons of dry tea per year. Nyabihu production is based almost exclusively on plantation tea, with smallholder tea accounting for 15 percent of the total acreage and 6.7 percent of the harvested area in 1985. The yields were almost identical for Nyabihu smallholder and plantation tea in 1985, but the plantation yield was only about 50 percent of that at Rubaya.

While the Rubaya plantation consists almost entirely of tea planted on hillsides, the composition of the total area of the plantation at Nyabihu in 1985 was approximately 43 percent on hillsides, the remainder being swamps.

Except for a very few hectares of forest close to the factory, Nyabihu does not use its own forest resources for firewood and must either buy the bulk of its firewood on the local and regional markets or work with electricity, both of which are very costly.

In contrast to Rubaya, the expansion of the tea plantation at Nyabihu partly took place by taking over smallholder cropland in 1983/84. In order to utilize established factory capacities, and as smallholder tea was not forthcoming because of poor profitability (see next section), costs of fixed capital—the factory—were "externalized," thus displacing farmers. Their farm area has since been devoted to plantation tea. The household-level effects of this expropriation are analyzed in Chapter 6.

*Profitability of Tea Production.* The profitability of tea production varies considerably among locations and factories, depending on the respective costs of production and processing, the local prices, and the profitability of alternative options of land and labor use.

In terms of costs of production and collection in Rubaya (as in some other factories), there seems to be a clear advantage for plantation tea compared with smallholder tea. Yields on the Rubaya plantation are among the highest in the country, which is a consequence of efficient management. On the other hand, yields on smallholder fields in Rubaya are among the lowest in the country.

The average costs of processing are twice as high in Rubaya (FRw 168 per kilogram of dry tea) and Nyabihu (FRw 130 per kilogram) as the average for the country (FRw 69 per kilogram). Part of this wide gap may be due to technological and managerial reasons.

A calculation of revenues (prices per kilogram minus total costs of production, processing, and domestic marketing) applied to the average of the two factories in Rubaya and Nyabihu[5] results in a negative economic return, independent of whether official or shadow exchange rates are used. However, the estimated economic profitability changes considerably if one assumes a drastic increase in the rate of capacity utilization and a reduction of processing costs corresponding to those achieved elsewhere in Rwanda.

In general, the economic analysis suggests that the procurement prices paid at farm level in the study area have been implicitly subsidized. In other words, if the factories had paid break-even prices, the financial profitability at farm level would have been significantly lower than that realized by farmers in the past.

Yet even at this implicitly subsidized price level, a clear comparative advantage in land and labor productivity does not seem to exist for smallholder tea production in the study area. Only a limited number of successful tea growers are able to obtain gross margins per person-day in the range of competing food crops, which stood around US$0.60 per day for sole stands of maize and US$0.70 for potatoes. The majority of the farmers find food production more attractive and tend to abandon tea insofar as administrative controls do not prevent them from doing so, or if not, an input for maintenance and harvesting is provided by the factories.

In summary, while smallholder tea production in Rwanda generally appears profitable and contributes efficiently to foreign exchange generation, this is clearly not the case in the study area. High processing costs due to underutilization of established factory capacities is the main reason, and the high unit cost of production of green tea in smallholder cultivation is the second factor. Full utilization of factory capacities would require expansion of the tea area at the cost of subsistence food production in this location. The opportunity costs of tea-production expansion are high and the consequences for household-level food security in the area require attention. Chapters 5 and 6 evaluate this in further detail.

### Expansion of Potato Production

In recent years, potato production has expanded rapidly in northwestern Rwanda, especially in the zone of the volcanic highlands, where environmental conditions are very favorable for potato production. In this region, market infrastructure—for potatoes in particular—is fairly well developed along the asphalted road linking Gisenyi and Ruhengeri. Along this road a large number of traders engage in potato marketing; they not only handle the interregional trade in potatoes by supplying all potato-deficit regions of Rwanda (and exporting to Zaire and Burundi as well) but have also set up an efficient input-provision network to supply farmers with knapsack-sprayers, pesticides, and improved seeds. (Scott [1986] provides a very useful description of the potato market situation in the area.) Potato production was further encouraged in the region by the installation of the *Programme National pour l'Amélioration de la Pomme de Terre* (PNAP) in Ruhengeri in 1979, with the support of the International Potato Centre (CIP). The main activities of PNAP are the selection, production, and distribution of improved varieties and extension.

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[5] The tea price of Rubaya factory is used here.

For Giciye and Karago *communes*, the acreage of potatoes was 8 percent and 38 percent, respectively, of total cropped area. There seems to be a tendency toward increasing acreages and yields of potatoes in the area. It has to be noted that these figures are only estimates of potato production on farmers' own fields and do not take into account the extent of potato production in the Gishwati forest area. The latter is a special case of potato production and a major source of recent commercialization in the study area.

Farmers and project employees of a reforestation and pasture-improvement project supported by the World Bank (GBK project) in the area cultivate potatoes, almost exclusively in sole stands, within the cleared and reforested areas of the former natural forest. Also, potato production has expanded rapidly into those parts of the forest that are outside the GBK project area. Potato production in the Gishwati region has a tremendous impact on the total potato production in the study area and on rural employment creation and food prices. The household-level data from the survey reported below provide further insights on this specific force of commercialization in the study area. Farmers from distant *secteurs* in the surrounding *communes* cultivate potato plots in the forest. Some of the plots are acquired through temporary leases from the reforestation project; others are occupied informally.

### Brewing of Sorghum Beer

An indigenous and important source of commercialization in rural areas of Rwanda is the manufacturing of sorghum beer and banana beer. In the survey area, only the sorghum beer is produced to a significant extent. Throughout Rwanda, there are an estimated 560,000 home brewers of sorghum beer (Haggblade and Minot 1987). The income, employment, and food consumption effects of sorghum beer brewing appear quite significant. Most of this brewing is done by women as a home production activity. Much of the produce is marketed. Sorghum beer production is affected by sorghum availability and labor availability, which leads to a somewhat seasonal pattern of beer brewing. Sorghum beer volumes are highest immediately after the sorghum harvest. Nationwide data indicate that sorghum beer brewing is more or less equally distributed across rural income groups. Home brewers in the bottom and top income quintiles each provide about 21 percent of total sorghum beer production (Haggblade and Minot 1987). The IFPRI survey results show that for this study area the importance of sorghum beer sales for total agricultural sales remains more or less the same across farm-size classes, and income from sorghum beer production is negatively but not significantly correlated with total income.

In the study area, sorghum beer sales represent about one-third of total sales of farm produce (in 1986) and contribute substantially to net farm income. Increased sorghum beer sales are highly correlated with an overall increase in marketed surplus. There is, however, substitution between wage earnings and home brewing of sorghum beer; the two are significantly negatively correlated in the household samples, which are reported in more detail below. Employment generation is significant for a population group—women—that does not participate very much in off-farm employment.

### Off-Farm Employment

Among the more important formal employers in the area, by order of importance, are the already-mentioned GBK reforestation project in the Gishwati forest; the two tea factories; the German development assistance project (*Projet d'Intensification des Productions Vivrières* [IPV]); road construction and infrastructure schemes; public works activities; and various activities of nongovernmental organizations.

As will be argued on the basis of primary household-level data below, off-farm nonagricultural employment is of considerable importance for commercialization in the study area, and much of this employment is directly or indirectly linked to specific development assistance projects. The rise and fall of projects creates a fair amount of instability in the rural labor market, an issue that requires further analysis.

After a brief discussion of the theoretical foundation, research design, and data collection for this research in the following chapter, detailed household-level results and respective analyses are presented.

## 4

# THEORETICAL FOUNDATION, RESEARCH DESIGN, AND DATA BASE

## Basic Relationships

The effects of commercialization on income and nutrition are mediated through complex relationships at the household level. Generally speaking, improvement of a household's or a person's nutritional status has to come through the ability to acquire more food, hence through growth of income or of resource endowments or both. An expected increase of income and production capacity is what motivates a household or individual household members to enter the exchange economy and become more commercialized. Thus, insofar as increased sale of produce, purchase of inputs, and off-farm employment occur on a voluntary basis, and insofar as the responsibilities and preferences within a household ensure sharing of gains, it can be expected that commercialization contributes to the household's food security.

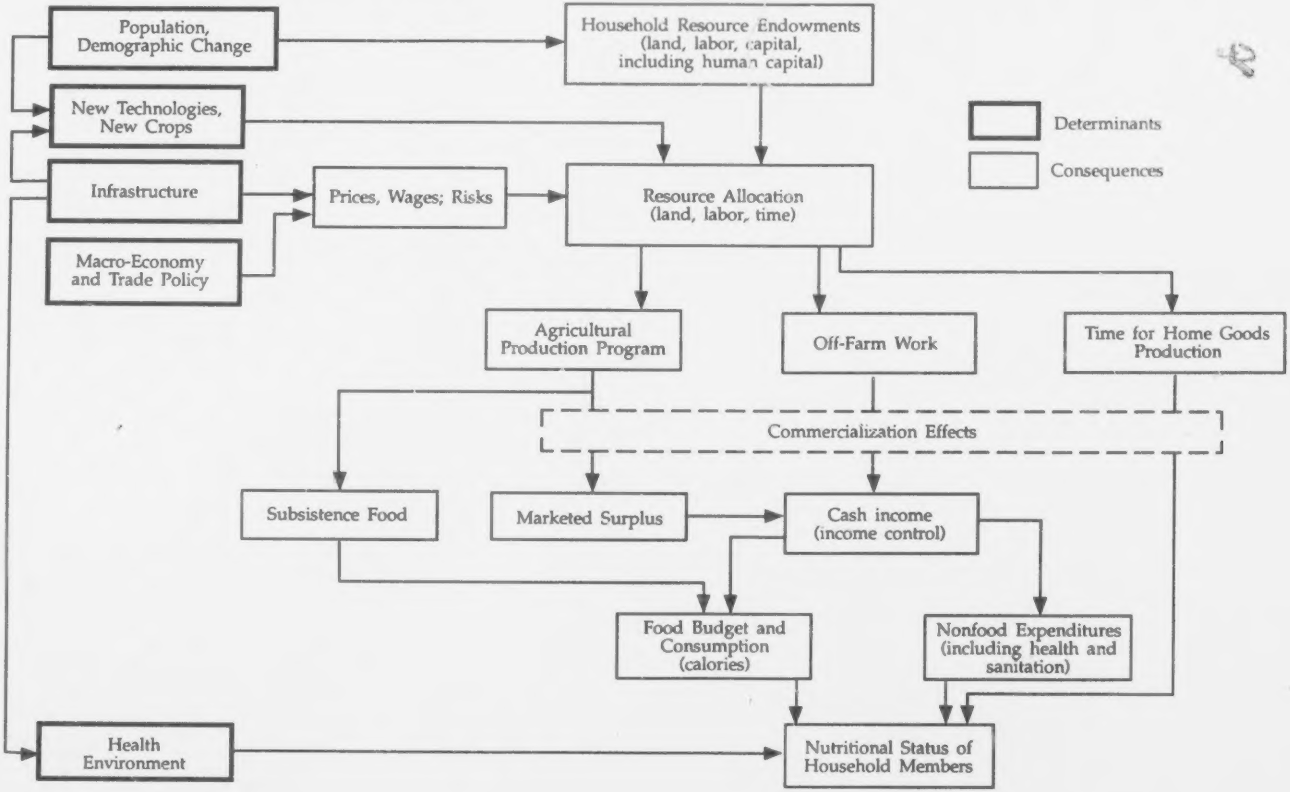
Yet the relationship is more complex when it comes to the real world of rural households, often characterized by structural imbalances, institutional constraints, and permanent changes of internal as well as external conditions. In spite of dynamic interdependencies of causes and effects, it may facilitate the analysis if exogenous factors that determine the commercialization are separated from the endogenous factors that tend to affect the influence of commercialization on income and nutrition. Figure 2 describes major relationships between both groups of factors.

Concerning the exogenous determinants of commercialization (left-hand side of Figure 2), among the most important driving forces are population change, availability of new technologies, markets and infrastructure, overall economic growth, and, finally, government policy related to these. Some of these factors may have more immediate and others only long-term effects on the farmer's decision to become more integrated in the market.

Demographic change is certainly a key determinant in the long run. It may facilitate or impede the commercialization of products, depending on the availability of resources. If an expansion of the cultivated area is still possible, so that the marginal labor productivity exceeds the marginal subsistence requirements, population growth may in fact enable an increase of the marketable surplus. Yet this situation has certainly become rare. Under the conditions in Rwanda, and with no significant change in the people's preference for a high degree of self-sufficiency in staple food, it is not unlikely that population growth might lead to a reduced volume of marketed surplus in relative or even absolute terms. On the other hand, it is likely that an increased person-land ratio might lead to an increased demand for off-farm employment in order to generate cash income, of which a high proportion will be spent on food.

The availability of new technologies, improved seeds and agronomic practices, on the one hand, and investment in infrastructure, price incentives from extended demand for agricultural products, and attractive wages and employment opportunities, on the other, are the other factors that facilitate the commercialization process. Of course, the second

Figure 2—Commercialization at the household level: determinants and consequences for income, consumption, and nutrition


Population, Demographic Change
Household Resource Endowments (land, labor, capital, including human capital)
New Technologies, New Crops
Determinants
Consequences
Infrastructure
Prices, Wages; Risks
Resource Allocation (land, labor, time)
Macro-Economy and Trade Policy
Agricultural Production Program
Off-Farm Work
Time for Home Goods Production
Commercialization Effects
Subsistence Food
Marketed Surplus
Cash income (income control)
Food Budget and Consumption (calories)
Nonfood Expenditures (including health and sanitation)
Health Environment
Nutritional Status of Household Members

group is closely related to the performance of the overall economy. Finally, commercialization can also be promoted by direct government action; namely, by various forms of compulsion related to the establishment of plantations (for example, tea or coffee), execution of certain management practices and input use, or forced procurement of produce.

The endogenous consequences of commercialization are also indicated in Figure 2. They relate to three different levels of decisionmaking within the households. One affects the allocation of the increased income for food and nonfood expenditures. It may be hypothesized that a reduced share or a reduced absolute volume of subsistence production will motivate a rise in the volume of purchased food and vice versa. The second decision level relates to how the available food budget is actually spent, that is, which types and which quantities of food are purchased and how these purchases are distributed over the year. Finally, the third decision is on how the available food is distributed among household members.

To understand how these decisions may be affected by the commercialization process, one has to consider other indirect consequences of commercialization, such as changes in the time allocation of men and women and in the control over the household's resources and cash income. For instance, it is not unlikely that—because of men's engagement in market production or off-farm work—women have less time for child care and home-based work and less control over the household's resources. Since men and women and younger and older people have different preferences in the allocation of a household's income for health care and nutrition, it is quite conceivable that commercialization may affect the situation of various family members differently, depending on how it changes the allocation of time, responsibilities, and control over income within a household.

## Explaining the Transition—Potentials and Deficits of Household Theory

The complexity of the relationships just described suggests that a comprehensive model of the rural household would be helpful in deriving hypotheses about the process of transition from subsistence toward full market integration. In fact, since Tschajanow (1923) first developed a theory of subjective household equilibrium, many authors have refined the model of the peasant household.

According to Tschajanow, a peasant family does not try to maximize a monetary profit but a subjective utility. Maximum utility is reached when the marginal drudgery of family labor in various activities is equated with the marginal goods and services gained from the labor input. Stimulated by Tschajanow, Nakajima (1970, 1986) developed a set of much more sophisticated subjective equilibrium models that basically postulate the same behavioral rules, with and without exchange with the external labor market. Nakajima not only specified a more formal mathematical structure that made it possible to trace the consequences of external changes, such as variations of wages, prices, and productivities on the household's labor allocation; he also specified certain properties of a family's indifference curves with a lower limit of income ("minimum subsistence") below which leisure has zero marginal utility and an upper bound ("achievement standard of living") above which income generated from further work has a marginal utility of zero. Nakajima's models describe the decision of household members to be engaged in wage employment or to employ hired labor in the farm household. Unfortunately, the models do not explicitly describe the factors that influence a household's decision concerning the allocation of resources between subsistence and market production. In essence the subjective equilibrium models assume a fully commercialized farm where a price can be imputed to all commodities.

In order to model the commodity side of the transition process, it would not only be necessary to introduce the distinction of subsistence and market production at the level of resource use, including labor; it would also be necessary to specify the underlying causal determinants, such as risk aversion, tasks, and habits, that may motivate a household to maintain a certain degree of self-sufficiency even at the cost of market income forgone. Moreover, nonmarketable household goods and services as well as market goods would have to have a common nonmonetary utility index.

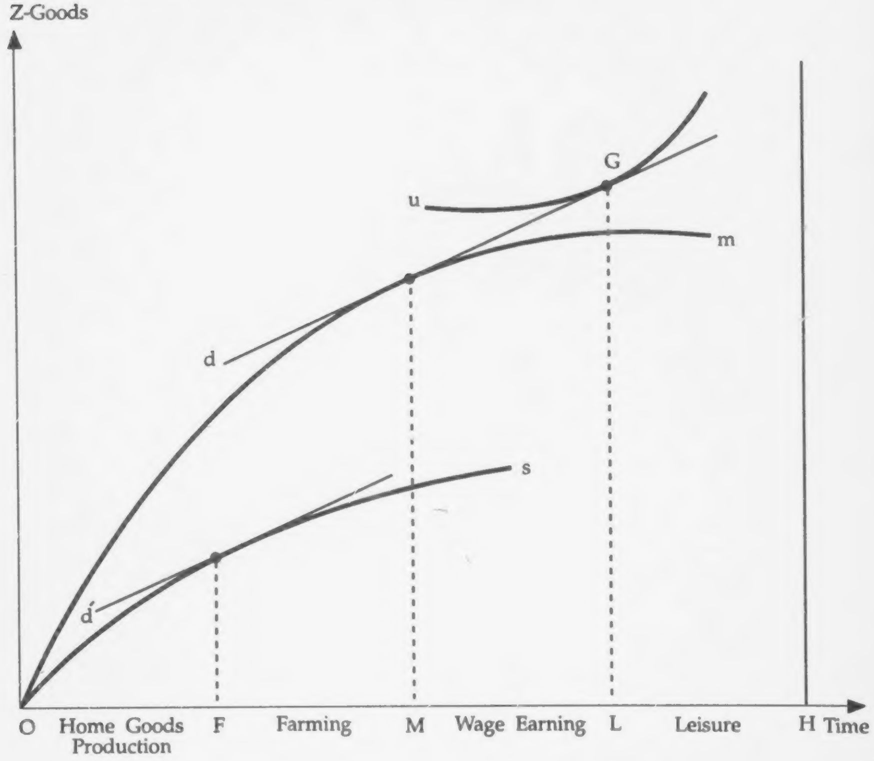
Fisk (1975) concludes from this that it is impossible to impute a price to a commodity that a farmer produces to meet his own family's needs without even considering exchanging it at the market. Fisk therefore postulates a complete separation of a subsistence enterprise and a monetary enterprise, whereby a household would first seek to maximize its utility in terms of physical subsistence goods and then, in a second step, allocate the remaining labor (and related resources) so that it maximizes its utility in terms of monetary income and leisure. Fisk is aware of dynamic forces that tend to reduce the marginal utility of subsistence production, namely, the establishment of effective local markets for agricultural and nonagricultural commodities, but also of changes in a household's consumption preferences and production technology. Thus "the subsistence component as a separate enterprise will tend to fade away" (Fisk 1975, 72). Yet this transition toward one unique monetary enterprise is not modeled explicitly.

The specification of a household's utility function in nonmonetary terms is one of the strengths of the modern theory of household economics, originating from Becker (1965) and Lancaster (1966). Models based on this theory postulate that a household's utility function is directly specified by a set of household-produced goods. These so-called Z-goods are produced by use of market or home-produced physical commodities in combination with the time input of household members. Maximization of a household's utility subject to a full-income constraint is then equivalent to minimizing the costs of producing a set of Z-goods, including leisure.

Using Evenson's (1978) application of this theory to a model of a peasant household, it seems in fact possible to include even the part of the subsistence production from household resources that cannot be used to produce market goods. This would normally include house and shelter, cooking facilities, and maybe a small home garden.

Figure 3 portrays the basic structure of the model. The composite Z-good is measured along the vertical axis, whereas the horizontal axis measures the working time, with the remainder of the full-time capacity (OH) being leisure. The curve s traces the production function for home goods, and curve m describes the combined production function of the household where agricultural production is added on the home production function. The basic assumption is made that the composite Z-good can be produced at home or purchased in the market. Purchased goods might not be identical but would be close substitutes for home-produced Z-goods. Thus the line d measures the opportunities in terms of Z-goods offered by the labor market. Its slope is defined as the wage rate divided by the goods price, indicating the purchasing power of the off-farm wage in terms of Z-goods (d′ is the parallel to d). Finally, u shows the indifference curve in terms of Z-goods and leisure.

Figure 3—Allocation of household time between home goods production, farming for the market, wage earning, and leisure



At equilibrium the household would have LH leisure time and LG Z-goods for consumption. It would spend OF units of time (and corresponding household resources) for home goods production, FM units of time for farm production, and ML units of time for wage earning. Thus the model postulates principally the same equilibrium conditions as the Nakajima-type model (Nakajima 1970, 1986): the marginal productivities of time in various activities in and outside the household are equated to the off-farm wage rate. But in addition, the physical specification of the utility curve enables inclusion of the home production as an extra domain of time allocation. Interesting hypotheses can be derived from this simple model:

- Increasing the wage rate raises the opportunity costs and hence motivates a reduction of the volume of home as well as farm production. It increases the incentive to seek wage employment and, depending on the position of the indifference curve, may also affect the overall time allocation between work and leisure.

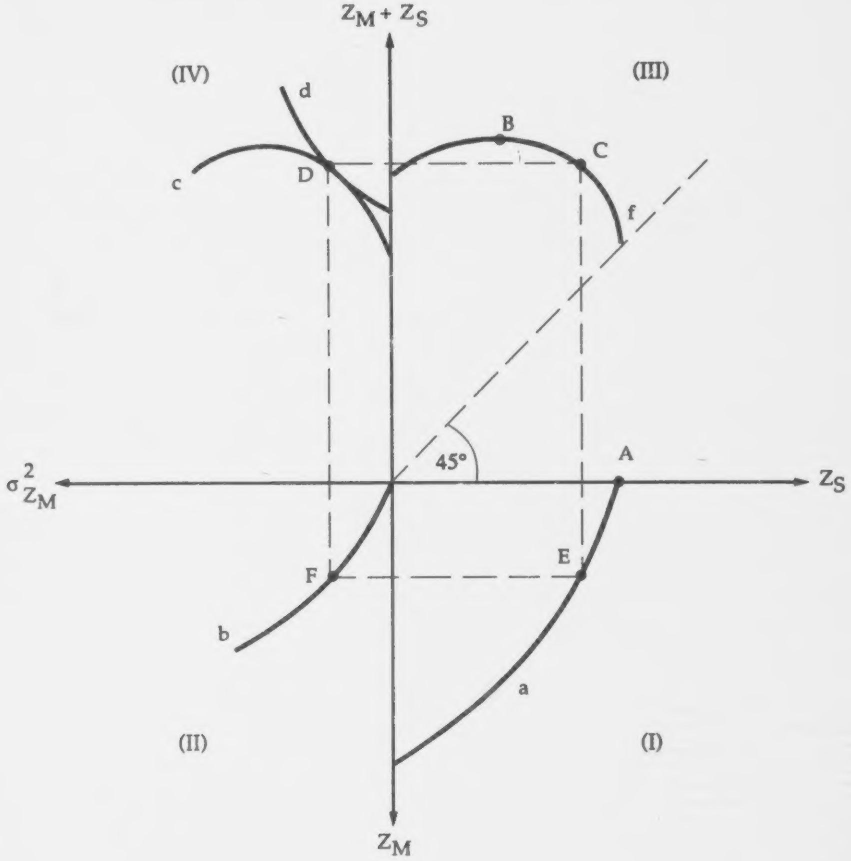
- Increasing the value of the Z-good reduces the purchasing power of the wage and therefore motivates an increase of the time spent in home production. Whether or not it also increases the time spent in farm production cannot be generalized on the basis of theoretical reasoning. It depends on the size of three separate effects: reduced opportunity costs of labor, increased price for the subsistence component of farm production, and reduced real price—that is, price expressed in Z-goods—for the market component of farm production. Thus the latter two may imply a shift of the farm production function.
- Increasing the productivity of farm work causes an upward shift of the overall production function. It motivates extended on-farm work and reduced off-farm work. Time allocated to home production is not affected unless the improved technology can also be applied on land—that is, home gardens—explicitly reserved for home production.
- Increasing the productivity of home goods production will also shift the combined production curve upward, but will mainly increase the time spent in the household and, depending on the shape of the home production curve, reduce either on-farm or off-farm work and possibly increase leisure.
- Increasing the family size will have complex implications for the household, depending on the effect on the labor force and the Z-good requirements, respectively. The impact on the demand for Z-goods includes needs for additional food, child care, and other household goods and services. This may increase the family's preferences for Z-goods instead of leisure. The effect on the family's labor force would, provided there exists a perfect labor market, essentially increase the family's demand for off-farm work and would not affect the internal time allocation. Yet, if additional employment cannot be found or can only be found at a reduced wage, the household would perceive reduced opportunity costs of labor and intensify the time spent in home and farm production.

In summary, there are a number of illuminating conclusions to be drawn from the model. Yet some of the aforementioned aspects of commercialization cannot be easily incorporated. Essentially the model assumes a complete separation of a family's resources for home production from those for farm production. Only the household's labor is being allocated between different types of activity. But the model does not explain how land and other resources are allocated to market and subsistence production. In order to derive preliminary hypotheses as to what motivates a household to adjust the share of resources determined for market production, the risks involved would at least have to be accounted for. Figure 4 portrays a simple model.

The household's production possibilities are indicated in section I of the figure. Curve a shows the transformation between Z-goods, namely food, that the household can directly produce for subsistence ($Z_S$), and Z-goods that the household can obtain by producing cash products and exchanging them for goods from the market ($Z_M$). Hence the curve's slope is not only determined by the physical production functions for subsistence and cash products, but also by the net price (gross margin) of the cash crop divided by the net price of the Z-good. Curve b (section II) indicates the market risks associated with an increased intensity of market exchange. Note that only those risks related to fluctuations of prices or availability of quantities are indicated here. Production risks are assumed to be identical in market and subsistence production. They do not enter the analysis.

Curve f (section III) represents the aggregate availability of Z-goods from subsistence and market exchange, as a function of the volume of subsistence production. The

Figure 4—Resource allocation to market versus subsistence production under risk



aggregate quantity is equivalent to the household's income. As the transformation curve is nonlinear, the aggregate has a maximum (B) somewhere between 0 and A—that is, at a degree of subsistence (subsistence divided by the total aggregate) between zero and one. Obviously, any extreme specialization on either subsistence or market production would be suboptimal due to declining marginal productivities (curve a). Finally, section IV portrays how the household might arrive at a decision concerning resource allocation for subsistence and market production by equating the marginal utility per unit of incremental aggregate production (curve c) with the marginal disutility due to the additional risks involved (curve d). A series of additional hypotheses can thus be derived about a household's decisionmaking:

- Risk-averse families may tend to keep subsistence production beyond the maximum income point (B)—say, at C, E— in order to keep the risk of market integration low (at F).
- A reduction of marketing risks—say, by improved infrastructure—(downward shift of curve b) and an increase of the profitability of marketing (downward turn of curve a through A) would both reduce the preference for a high degree of subsistence.
- Increasing a household's total resources (right shift of curve a) would most likely motivate a decline in the degree of subsistence, probably going along with an increased absolute volume of subsistence production.

In total, one can summarize that the available models of the rural household do not lead to a consistent specification of all basic relationships that were shown to be relevant for the commercialization process, but they do allow some important partial hypotheses insofar as the exogenous determinants of a farm's transition into the market is concerned. The state of model building and theory is still much less advanced when it comes to the endogenous factors that determine the allocation of income and the distribution of basic goods, food in particular, inside the household.

## Analytical Approach

Some of the hypotheses derived from the preceding analysis will be subject to empirical tests in the following chapters. No attempt will be made to use a complete structural form of a household model for these empirical tests, since much information on important relationships would be lost in aggregation. Nor is a complete household model approach taken, partly because of the indicated deficits in modeling the complex interdependencies within rural households, but also because of limitations in data, especially data concerning marketing risks—which would require longer time series—and household preferences. Instead, the analytical approach comprises a set of equations describing the key relationships involved in the commercialization process. They relate to a household's time allocation, sources of income, spending of income, and determinants of the degree of subsistence. This degree will be measured following different concepts of market integration. Finally, the nutritional status of the rural family will be related to various factors that are subject to change during the commercialization process.

The actual analysis at the household level is carried out as sketched in Figure 2 in an attempt to trace some of the more relevant exogenous forces of commercialization to their effects on resource allocation, patterns of commercialization, consumption, and nutrition. Before discussing that, however, a clear specification of subsistence concepts will be given.

The term subsistence is used in two different ways. First, it is used as a concept that describes production of goods for consumption by the household. Second, subsistence is a concept that describes a minimum standard of physical and mental survival and productive efficiency (a comprehensive survey of literature on this concept is provided, for instance, in Sharif 1986).

In this study, the term subsistence is used in the sense of the first definition mentioned above. Accordingly, the term commercialization defines the volume of produce and household resources that enter the exchange economy. This may include sales or barter of farm products not used for subsistence and off-farm employment of labor and capital.

The extent of subsistence orientation and commercialization of farm households and the rural economy may be addressed from three different angles.

Agricultural subsistence orientation (concept 1) is measured by the extent to which farm households consume out of their aggregate agricultural produce as compared with the value of total agricultural produce:

$$CA = AS/AP, \tag{1}$$

where CA is the agricultural subsistence ratio, which is the ratio of the value of non-marketed agricultural produce (AS) over the total value of agricultural production (AP).

In addition to this output-oriented concept, it can be imagined that subsistence agriculture develops toward "commercialization" on the input side but not on the output side; for instance, when farm households sell their labor in the off-farm labor market and invest proceeds in augmenting their subsistence production.

A more comprehensive concept of commercialization will take into account the overall degree of market integration of rural households into the exchange economy and does not just look into agriculture. This may be approached from two different angles, the income earning side and the consumption side.

Subsistence orientation at the income generation side of the household (concept 2), can be defined as follows:

$$CY = AS/Y_{tot}, \tag{2}$$

with total income $Y_{tot}$ being

$$Y_{tot} = AP - AC + Y_o + Y_w + Y_l, \tag{3}$$

where

$CY$ = subsistence share in total income,
$AC$ = cost of agricultural production,
$Y_o$ = any other income from transfers or renting out assets (such as land),
$Y_w$ = off-farm wage income (from integration into the labor market), and
$Y_l$ = income equivalent of leisure.

Subsistence orientation at the consumption side (concept 3) may be evaluated with the ratio CX:

$$CX = X_s/X_{tot}, \tag{4}$$

where CX is the subsistence share in total consumption, $X_s$ is the total value of goods consumed out of home production, and $X_{tot}$ is the total consumption value of the household, including purchased and own-produced items for consumption, such as the value of subsistence food.

The above measures (concepts 2 and 3) capture market integration/penetration of households beyond agricultural market integration. Landed rural households may commercialize through specialization in crop production or shifts in production functions through technical change combined with increased input demand (integration in input markets). Also, farm households may commercialize via increased off-farm work partly at the expense of marketed surplus from agricultural production. This means that there may be substitution effects between (AP - AC) and $Y_w$, leaving CY in equation (2) rather stable, with different patterns of subsistence orientation.

In fact, the sources of commercialization are manifold at the study location; the picture would be distorted if only the process of agricultural commercialization (concept 1) were presented here, as will be shown later. The process of commercialization of traditional agriculture is rarely just a switch from subsistence food to a cash crop, as already highlighted in the context of the descriptive account of the driving forces of commercialization in this study area.

Functional relationships, as depicted in Figure 2, are addressed in models that attempt to explain the key relationships. A simplified descriptive sketch of these models is given below. Details on specifications follow in the respective sections of the report.

Aggregate agricultural production (AGPROD), whether for the market or for home consumption, is a function of a household's resource endowments and technology. Thereby,

$$\text{AGPROD} = f(\text{Land, Labor, Capital, Technology, Environment}). \qquad (5)$$

Total agricultural income may be derived from AGPROD and related prices and wages. Agricultural labor productivity of the household is thus a function of resource endowments, technology, and so forth.

The off-farm work time (OFFWORK) as a key choice of market integration at the study location is expected to be determined, among other things, by the off-farm wage rate versus agricultural labor productivity, as work time off-farm competes with time spent for on-farm production:

$$\begin{aligned}\text{OFFWORK} = f(&\text{Off-Farm Wages, Agricultural Labor Productivity,}\\ &\text{Demographic Composition of Households, Location}). \qquad (6)\end{aligned}$$

It is of particular interest to trace the effects of commercialization and subsistence orientation to the household's budget for food and to calorie consumption levels (CALOR). This also tests for the effects of more integration into the cash economy on the level and composition of food consumption, which may be affected by changes in income control and income composition in the household:

$$\begin{aligned}\text{CALOR} = f(&\text{Demographic Composition, Total Income, Food-Cash}\\ &\text{Ratio of Income, Women's Income Control, Prices}). \qquad (7)\end{aligned}$$

Explanation of individual children's nutritional status in terms of their weight-for-age and other related indicators (NUTSTAT) is attempted to trace the effects from changed income level and spending via consumption to nutritional outcome. Food consumption as explained in (7) above is thus related to the nutritional situation given the household's health environment (see also Figure 2):

$$\begin{aligned}\text{NUTSTAT} = f(&\text{Child Demographics, Household Demographics, Food}\\ &\text{Energy Consumption, Health Environment}). \qquad (8)\end{aligned}$$

The specifics of these models are discussed in the respective chapters of the report.

# 5

# PRODUCTION AND INCOME EFFECTS OF THE COMMERCIALIZATION PROCESS

In this chapter, household subsistence orientation is quantified and discussed along the lines of the three alternative concepts described in Chapter 4. Then the agricultural production system is described, especially the use of labor, and the determinants of productivity of land and labor in the subsistence and commercialization subsectors of agriculture. The next section then focuses on off-farm work and employment in nonagriculture sectors, as these growing sources of employment are contributing much to commercialization of the rural economy. A description of the sampling and data collection that form the basis of these analyses is in Appendix 1.

## Household Subsistence Orientation: Concepts and Basic Patterns

Average farm size in the study area is 0.74 hectare; it is 0.64 hectare if the land in the Gishwati forest is excluded (Table 6). The bottom 25 percent (lowest quartile) of farms have an average of only 0.23 hectare of land. The smallest farms have absolutely and relatively less land in Gishwati and support smaller households (3.9 persons versus the sample average of 5.1), and their household heads are younger (36.7 years versus the average of 42.5). The younger age of farmers in the lowest quartile is probably found because those farms resulted from land fragmentation during recent inheritances.

The three alternative concepts discussed in Chapter 4, assessing household subsistence orientation, are presented with their quantitative results in Table 7. Agriculture in the study area is still considerably subsistence-oriented. According to concept 1—which expresses the value of subsistence production as a percent of total agricultural production—69.2 percent of agricultural production is for home consumption. Also, taking the broader approach of concept 2—which relates the value of subsistence production to total

**Table 6—Household size and landholdings, and age of household head, 1985/86**

| Farm-Size Group | Farm-Size Average: Total Land | Farm-Size Average: Land in Gishwati Forest | Average Persons per Household | Average Age of Household Head |
|---|---|---|---|---|
| | (hectares) | | | (years) |
| Bottom quartile | 0.23 | 0.03 | 3.9 | 36.7 |
| Second quartile | 0.45 | 0.04 | 5.1 | 39.8 |
| Third quartile | 0.75 | 0.06 | 5.6 | 45.3 |
| Top quartile | 1.53 | 0.29 | 5.9 | 48.1 |
| Average | 0.74 | 0.10 | 5.1 | 42.5 |

Source: International Food Policy Research Institute survey, 1985/86.

## Table 7—Alternative concepts assessing household subsistence orientation, by person-land ratio and total expenditure quartiles, 1985/86

| | Concept 1 | Concept 2 | Concept 3 |
|---|---|---|---|
| | Value of Subsistence Production | | Value of Consumption from Own Production in Percent of Total Value of Consumption of Foods and Nonfoods |
| Group | In Percent of Total Agricultural Production Value | In Percent of Total Income | |
| Person-land ratio quartiles (averages in persons/hectare) | | | |
| Bottom quartile (21.3) | 77.4 | 30.1 | 41.1 |
| Second quartile (11.5) | 66.5 | 37.4 | 47.2 |
| Third quartile (7.4) | 69.4 | 38.6 | 52.2 |
| Top quartile (4.1) | 68.4 | 39.0 | 49.9 |
| Total expenditure quartiles[a] (averages in FRw) | | | |
| Bottom quartile (6,303) | 67.1 | 41.5 | 50.0 |
| Second quartile (8,692) | 74.8 | 52.4 | 50.0 |
| Third quartile (11,698) | 72.5 | 44.7 | 52.0 |
| Top quartile (19,037) | 57.2 | 22.6 | 43.5 |
| Total average | 69.2 | 36.9 | 47.8 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] Annual expenditure per capita, including the value of food consumed from own production (this may be viewed as an income proxy).

income, including off-farm and nonagricultural income and transfers—it was found that subsistence food production represents a high share (about 36.9 percent) of total income. Likewise, according to the consumption-oriented concept 3—which relates the value of consumption from own-production to the total value of consumption of foods and nonfoods—47.8 percent of total consumption values are from own production.

Concepts 2 and 3 should, in principle, give similar values of subsistence orientation if there were no savings and dissavings,[6] and if producer prices of food were equal to consumer prices.[7] Of course, these are strong assumptions, and considerable differences between the two concepts can be expected. It was found that especially in the bottom and top expenditure quartiles, the difference between the two concepts widens, while in the two middle quartiles the two concepts are quite consistent (Table 7). Usually consumption and expenditure survey data are more trustworthy than income surveys. If this may also be assumed here, two factors could be at play explaining the different results: one, that agricultural subsistence income is underestimated or total income overestimated in concept 2, thereby decreasing the subsistence percentage; and two, that savings may play a substantial role, at least at the top of the income distribution, thereby resulting in the different outcomes in the two concepts. While the first factor would reflect a data quality problem, the second would be a legitimate reason for an expected deviation between the figures in the two concepts. A definite answer is not possible.

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[6] Minor deviations can be expected, as the period of the consumption survey (1986) is not identical with that of the income survey (1985/86).

[7] In concept 2 (income concept), producers' selling prices are applied to value the nonmarketed food production.

A striking result of this assessment of household-subsistence orientation from various angles is the weak relationship of subsistence orientation, both with land endowment (person-land-ratio) and with household income level, as represented by total expenditure. It is only in the top quartile that a clear reduction in the relative importance of subsistence shows up (bottom of Table 7, concepts 2 and 3). Behind this, however, is a higher absolute value of subsistence production in the top income groups.

Also quite striking is the result depicted by concept 1—that agricultural market integration does not increase significantly with increased land endowment in the range of this sample. The most land-scarce group, with an average of 21.3 persons per hectare, retained 77.4 percent of their production in value terms, and the group with the lowest person-land ratio retained 68.4 percent. The aggregate marketed surplus is, on average, 31.6 percent from sorghum beer, 31.5 percent from Gishwati potatoes (in 1986), and the rest from other crops and livestock. Sorghum beer sales are particularly important for the most land-scarce households (61.8 percent of sales value; see Table 8, column 2), while potatoes in Gishwati are more important for the land-rich households.

Although subsistence orientation is high, on average, the degree of agricultural subsistence orientation (concept 1) varies a great deal between households. Ranking households by that degree shows that the top quartile (that is, the most subsistence-oriented and least market-integrated) sells only goods equivalent to 4.2 percent of the total value of production, while the bottom quartile sells 57.8 percent. The share of land in Gishwati correlates positively with increased commercialization (Table 9, rows 2 and 3).

This is a rural economy with much part-time farming. More than half of the income is earned off-farm (Table 10, column 3). No clear-cut relationship between total income and degree of agricultural subsistence orientation is visible from the simple tabulation (Table 9, last row).

In Table 10, households are ranked by the relative importance of subsistence production over total income—that is, according to subsistence concept 2. If households are ranked according to this more comprehensive subsistence concept, the households

Table 8—Farm size, subsistence orientation in agricultural production (concept 1), and main sources of market integration, 1985/86

| Person-Land-Ratio Group | Value of Subsistence in Percent of Total Agricultural Production Value (Concept 1) | Value of Sorghum Beer Sales in Percent of All Sales of Farm Produce | Value of Gishwati Potato Sales in Percent of All Sales of Farm Produce |
|---|---|---|---|
| Bottom quartile (land poorest) | 77.4 | 61.8 | 15.2 |
| Second quartile | 69.4 | 45.5 | 11.4 |
| Third quartile | 66.5 | 29.7 | 25.0 |
| Top quartile (land richest) | 68.4 | 15.5 | 53.9 |
| Average | 69.2 | 31.6 | 31.5 |

Source: International Food Policy Research Institute survey, 1985/86.

## Table 9—Subsistence orientation of agriculture (concept 1) and income sources, 1985/86

| Item | Subsistence Orientation in Agricultural Production (Concept 1) | | | | |
|---|---|---|---|---|---|
| | Bottom Quartile (Least Subsistence-Oriented) | Second Quartile | Third Quartile | Top Quartile (Most Subsistence-Oriented) | Average |
| | (average value of sample) | | | | |
| Value of sales in percent of agricultural production value | 57.80 | 29.90 | 15.00 | 4.20 | 32.50 |
| Total farm size (hectares) | 0.87 | 0.79 | 0.56 | 0.72 | 0.74 |
| Land in Gishwati (hectares) | 0.17 | 0.07 | 0.08 | 0.06 | 0.10 |
| Value of subsistence production per capita (average = 100) | 87 | 92 | 94 | 127 | 100 |
| Value of total income per capita (average = 100) | 110 | 118 | 76 | 95 | 100 |

Source: International Food Policy Research Institute survey, 1985/86.

## Table 10—Subsistence orientation (concept 2) and income from other sources, 1985/86

| Group by Degree of Subsistence over Total Income[a] (Concept 2) | Farm Size | Total Income per Capita (Average=100) | Off-farm Income per Capita | Wage Income per Capita |
|---|---|---|---|---|
| | (hectares) | (average value of sample) | (percent of total income) | |
| Bottom quartile (least subsistence-oriented) | 0.75 | 172.0 | 80.1 | 50.9 |
| Second quartile | 0.61 | 92.7 | 46.6 | 38.5 |
| Third quartile | 0.74 | 82.3 | 32.6 | 26.5 |
| Top quartile (most subsistence-oriented) | 0.86 | 54.1 | 15.4 | 8.9 |
| Average | 0.74 | 100.0 | 57.5 | 39.3 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] Total income includes off-farm income, transfers, and remittances.

with the highest degree of subsistence orientation turn out to be the poorest in income terms (Table 10, column 2). It is also interesting to note that the off-farm income share is highest (80.1 percent) in those households that have very little subsistence production, and these households also have the highest share of wage earnings (Table 10, columns 3 and 4).

Although farm size does not show a consistent variation in the above tabulations along classes of subsistence and commercialization, the land base of households is, of course, a major factor that determines households' income earning at this location. Grouping farms in quartiles by farm size shows that the top 25 percent (with an average 1.53 hectares) has farms 6.7 times larger than the bottom quartile (0.23 hectare); on a land-per-capita basis, the top quartile has 4.4 times more land per person than the bottom quartile. Farm income per capita in the top quartile, however, is "only" 1.7 times higher than that in the bottom quartile (Table 11, column 2). This suggests that the smaller farms make up for a large proportion of the difference in size by higher land productivity. This will be further explored in the following section and plays a key role in the long-term simulations discussed in Chapter 8.

A surprising result of this assessment is that per capita off-farm income rises at least as much as does farm income with increased farm size. Therefore, the share of total off-farm income for the larger farms is roughly the same as for the small farms (Table 11, column 5). Wage incomes, however, decrease with rising farm size.

An important research undertaking is to identify the measures that farmers take to increase returns to land (and labor) on their increasingly limited land base as well as the role that new crop technology plays in this context. For this purpose, a detailed descriptive and analytical account of the production system and of determinants of productivity in agriculture follows. Also, the important nonagricultural income sources that largely determine the degree of commercialization at the location need to be better understood in order to identify ways to induce the expansion of productive employment in the nonfarm sectors. This is approached in a later section.

## The Agricultural Production System

This section makes extensive use of the detailed farm- and plot-specific information, including yield and labor data, that were collected for a subsample of 20 percent of the main sample. For internal consistency, most of the information in this section refers to this subsample only. The subsample households are somewhat less land-short than the main sample. Farm size is 0.86 hectare as compared with 0.74 hectare in the main sample.

Table 11—Income by farm-size group, 1986

| | | | | Share of Income from | |
|---|---|---|---|---|---|
| **Farm-Size Group** | **Farm Size (Average of Group)** | **Farm Income per Capita (Average=100)** | **Total Income per Capita (Average=100)** | **Agriculture[a]** | **Total Off-Farm Income** |
| | (hectares) | (average value of sample) | | (percent of total income) | |
| Bottom quartile | 0.23 | 76.6 | 71.5 | 46.8 | 53.2 |
| Second quartile | 0.45 | 91.2 | 96.4 | 40.9 | 59.1 |
| Third quartile | 0.75 | 104.8 | 85.4 | 56.1 | 43.9 |
| Top quartile | 1.53 | 127.0 | 146.5 | 35.7 | 64.3 |
| Average | 0.74 | 100.0 | 100.0 | 42.5 | 57.5 |

Source: International Food Policy Research Institute survey, 1985/86.

Note: The data in this table cover only January-October, 1986.

[a] Including income from sorghum beer.

The farming systems prevailing in the study area are exclusively based on smallholder agriculture, with family labor providing the bulk of total labor inputs. Table 12 summarizes the subsample family size, total farm size, and origin of farmland by different modes of acquisition. In the table, two different farming systems are distinguished according to altitude—below 2,280 meters for the first group, and above 2,280 meters for the second. The lower-altitude systems are more sorghum/sweet potato/beans-oriented, while the higher-altitude systems are more maize/peas-oriented (Table 13). The person-land ratio, expressed in adult-equivalent persons per hectare, is significantly higher for the lower-altitude group (Table 12).

Looking at the different modes of land acquisition, Table 12 reveals that, on average, 62 percent or 0.53 hectare of the total area is owned (that is, inherited or bought), 17 percent is rented for cash, and 11 percent is obtained without payment, mostly through the extended family.

The main reason for the larger proportion of Gishwati land in the higher-altitude group is that those households directly border on the Gishwati forest and thus have easier access to Gishwati fields.

According to the climatic conditions of the study area—mainly the bimodal pattern of rainfall distribution—two agricultural seasons are to be distinguished: the first season starts with the onset of the rains in mid-September and ends in late February or early March, while the second season covers the rest of the year.

The agricultural production systems of the study area are almost entirely based on food-crop production. Land use is dominated by the main cereals. On average, maize (30 percent or 0.26 hectare) and sorghum (17 percent or 0.15 hectare), both in sole stands and under mixed cropping, account for almost half the total farm size, followed by sweet potatoes and peas with approximately 15 percent (or 0.13 hectare) each, the remainder being beans and wheat and other crops of minor importance (Table 13). Cultivation of potatoes outside the Gishwati area is of only little importance.

Farmers practice both mixed cropping and sole-stand cropping for the main cereals and beans, but the system of mixed cropping is preferred. The agricultural production technology is almost exclusively based on manual labor, with the hoe and machete being the most important and sometimes the only agricultural tools. The only exception to this is the employment of knapsack sprayers to treat potatoes against late blight, but such spraying is limited to the cultivation of potatoes in the Gishwati area. Apart from that, no pesticides are used in food crop production.

So far, the application of mineral fertilizers is mainly found in agricultural development projects and tea plantations. A program of fertilizer distribution to progressive, successful farmers during 1984-87 reached out to only a few producers in the study area.

Although improved varieties exist for some crops like peas, beans, and wheat, at present their use is not very widespread. Potatoes are the only exception. There is a considerable range of improved potato seeds, selected and distributed by PNAP in particular, and farmers make more widespread use of them. No improved varieties of maize and sorghum are available so far for the higher-altitude regions of Rwanda.

At the end of 1985, animals were kept in 79 percent of all sample households. The average number of cattle was 0.6 in households that kept any animals, but only 37 out of 190 farms kept cattle. There is a high degree of variation within the sample—45 out of a total of 84 cattle (or 54 percent) were owned by only 3 households. Goats were kept by 115 (or 61 percent) of all sample households; sheep were kept by 88 households (or 46

## Table 12—Farm size, source of land acquisition, and labor-land relationships in subsample households, 1986

| Item | All Subsample Farm Households | | Lower-Altitude Group (N=21) | | Higher-Altitude Group (N=21) | |
|---|---|---|---|---|---|---|
| | Average | C.V.[a] | Average | C.V.[a] | Average | C.V.[a] |
| Farm size and land acquisition | | | | | | |
| Farm size without land in Gishwati (hectares) | 0.86 | 0.68 | 0.74 | 0.59 | 0.98 | 0.70 |
| Farm size with land in Gishwati (hectares) | 0.75 | 0.60 | 0.70 | 0.61 | 0.79 | 0.60 |
| of which percent[b] - inherited | 42.2 | 0.76 | 36.6 | 0.84 | 47.6 | 0.70 |
| - bought | 20.3 | 1.25 | 26.0 | 1.14 | 14.6 | 1.33 |
| - cash rental | 16.6 | 0.95 | 18.2 | 0.93 | 15.0 | 0.97 |
| - obtained free[c] | 10.9 | 2.10 | 14.4 | 1.97 | 7.3 | 2.19 |
| - rented out | 1.3 | 3.31 | 0.7 | 4.51 | 2.0 | 2.58 |
| - Gishwati | 8.7 | 1.49 | 4.1 | 2.73 | 13.5 | 1.00* |
| Average number of plots[b] | 10.8 | 0.36 | 11.5 | 0.35 | 10.1 | 0.38 |
| Average size per plot (square meters)[b] | 806.0 | 0.56 | 621.0 | 0.40 | 991.0 | 0.58** |
| Labor-land relationships | | | | | | |
| Family size (persons) | 4.98 | 0.43 | 5.19 | 0.40 | 4.76 | 0.47 |
| Person-equivalents[d] | 2.67 | 0.47 | 2.63 | 0.46 | 2.71 | 0.49 |
| Person-land ratio (person-equivalents per hectare, including Gishwati land) | 3.95 | 0.52 | 4.70 | 0.51 | 3.27 | 0.46* |
| Person-land ratio (person-equivalents per hectare, excluding Gishwati land) | 4.48 | 0.51 | 5.10 | 0.53 | 3.93 | 0.43 |

Source: International Food Policy Research Institute survey subsample, 1986.

[a] C.V. = coefficient of variation.

[b] Derived from total farm size, including land in Gishwati.

[c] Land obtained for use without payment, mostly through family links.

[d] For definition, see Appendix 2, Table 56.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

## Table 13—Land allocation of subsample households, 1986

| Crop | All Subsample Farm Households | | Lower-Altitude Group (N=21) | | Higher-Altitude Group (N=21) | |
|---|---|---|---|---|---|---|
| | Average | C.V.[a] | Average | C.V.[a] | Average | C.V.[a] |
| | (percent)[b] | | (percent)[b] | | (percent)[b] | |
| Maize (mixed cropped) | 19.1 | 0.97 | 11.3 | 0.97 | 27.0 | 0.79** |
| Sorghum (mixed and sole stands) | 16.8 | 2.18 | 22.9 | 1.82 | 10.6 | 2.97* |
| Sweet potatoes | 15.5 | 0.86 | 22.9 | 0.55 | 8.1 | 1.19** |
| Peas | 15.4 | 1.16 | 8.5 | 1.58 | 22.4 | 0.85** |
| Maize (sole stands) | 10.9 | 1.25 | 10.8 | 1.24 | 11.1 | 1.29 |
| Beans (mixed and sole stands) | 6.3 | 2.29 | 10.0 | 1.94 | 2.7 | 2.35* |
| Wheat | 2.0 | 3.05 | 0.8 | 2.20 | 3.2 | 2.66 |
| Tobacco | 0.1 | 7.00 | 0.1 | 5.00 | 0.2 | 4.74 |
| Other (such as vegetables, fuelwood, and potatoes outside Gishwati area) | 3.0 | ... | 4.0 | ... | 2.0 | ... |

Source: International Food Policy Research Institute survey subsample, 1986.

[a] C.V. = coefficient of variation.

[b] Derived from total farm size without land in Gishwati.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

percent). Except for poultry, where an average of 3.4 chickens were kept by 22 percent of all sample households, the importance of any other domestic animals is very limited. In terms of tropical livestock units (TLU, as defined in Jahnke 1982, 10), the respective figures are 0.81 TLU per household for the whole sample and 1.02 TLU for those who kept animals. For the latter, this corresponds to 1.41 TLU per hectare of farmland, which is rather high compared with livestock densities found in other regions of tropical highlands in Africa.

The number of TLU per household is positively correlated with total farm size (0.55). The number of cattle is significantly higher for the higher-altitude group, and to a lesser extent the number of goats, too. It has to be kept in mind that the higher-altitude parts of the study area directly border on the Gishwati forest and that a substantial number of cattle are kept in cooperatives of the Gishwati GBK project, thus not depending on the supply of fodder from farmland outside the Gishwati area.

## Labor Use and Division of Labor in Agriculture

### Labor Time Allocation

On average, the total labor input for agricultural field work was 198 person-days per household per year (September 1985 to August 1986). Family labor provided an average of 73.9 percent to the total labor input, while the share of nonfamily labor averaged 26.1 percent. While the agricultural labor input per adult family member (that is, household members of 15 years of age and above) was found to be rather low and averaged 63 person-days per year, the average total labor time per adult family member amounted to 154 person-days (Table 14). The difference is due to the time spent on the reciprocal

Table 14—Average labor time allocation in person-days per adult family member, 1985/86

| | Adult Family Member[a] | | |
|---|---|---|---|
| Labor Allocation | Days | Percent of Total | C.V.[b] |
| Agricultural labor on own farm | 63 | 40.9 | 0.35 |
| Reciprocal agricultural labor exchange with others | 15 | 9.7 | 0.70 |
| Off-farm labor | 30 | 19.5 | 1.25 |
| Other activities[c] | 46 | 29.9 | 0.59 |
| Total | 154 | 100.0 | ... |

Source: International Food Policy Research Institute survey subsample, 1985/86.

[a] Weighting family members above 55 years of age by 0.6.

[b] C.V. = coefficient of variation.

[c] These include, among others, construction, repair and maintenance of houses, stores and stables, rural handicrafts, anti-erosion activities, sorghum beer production, and some social activities.

exchange of agricultural labor with other households, on off-farm work, and on other activities not directly related to agricultural production.

According to the agricultural seasons and the respective cropping patterns, the average monthly labor input for agricultural activities follows a distinct seasonality, with the most important labor peak occurring in September, when the average labor input was 33 person-days per household. The main activities recorded for this month were the weeding of maize and sorghum, and soil preparation for and planting of peas and beans. A second peak occurred during the months of May and June (25 and 20 person-days, respectively), a period almost exclusively dedicated to soil preparation for and planting of maize and sorghum. Another important peak found in November was due to high labor requirements for the second weeding of the main cereals as well as soil preparation for and planting of sweet potatoes.

The distinct seasonality of the total agricultural labor input per month is not leveled off by the employment of nonfamily labor. However, because the average family labor input for off-farm employment does not vary much between months, the coefficient of variation in the total family labor input for agricultural and off-farm activities is lower than it is for agricultural fieldwork alone.

Table 15 summarizes the allocation of the total labor input to different crops, the total labor input in person-days per hectare for the most important crops (and for leading crops in crop mixes), and the composition of the total labor input according to family and nonfamily labor. The total labor input is highest for potatoes, with 434 person-days per hectare, and is lowest for peas, with 142 person-days per hectare. The respective shares of family and nonfamily labor do not vary much for the different crops. The contribution of family labor was found to be lowest in the case of sorghum (70 percent), followed by peas (71.8 percent) and maize (71.6 percent), while it was highest for cultivating beans (86.3 percent) and sweet potatoes (82.7 percent).

## Women's Predominant Role in Agriculture

Men contributed on average 25.3 percent of total family labor input in agriculture (19 percent for the household head and 6.3 percent for male adults above 15 years of age).

**Table 15—Allocation of total labor input by crop and by family and nonfamily labor, 1985/86**

| Crop | Percent of Total Labor Input | Total Labor Input per Hectare | Percent of Family Labor | Percent of Nonfamily Labor |
|---|---|---|---|---|
| | | (person-days) | | |
| Maize | 21.2 | 306 | 71.6 | 28.4 |
| Sorghum | 18.1 | 404 | 70.0 | 30.0 |
| Potatoes | 19.5 | 434 | 77.0 | 23.0 |
| Sweet potatoes | 15.2 | 398 | 82.7 | 17.3 |
| Peas | 7.2 | 142 | 71.8 | 28.2 |
| Beans | 5.9 | 400 | 86.3 | 13.7 |
| Other crops | 12.9 | n.a. | n.a. | n.a. |
| Total | 100.0 | ... | ... | ... |

Source: International Food Policy Research Institute survey subsample, 1985/86.

Notes: n.a. means not applicable. Labor allocation to crops in mixed cultivation was identified in the plot-specific surveys by taking account of the share of the respective crop in the plot's output as far as activities applicable to the joint crops are concerned (for example, weeding).

While the wife of the household head provided 68.6 percent, women's total share amounted to a total of 74.1 percent when adult daughters were included. The contribution of both male and female children below 15 years of age did not exceed 0.6 percent on the average (Table 16).

For all crops and activities, the share of women's labor is higher than it is for men. Men's participation is important for soil preparation and harvest activities, while planting and weeding are predominantly tasks of women. The only exception to this is in potatoes and, to a lesser extent, sorghum, where men contribute considerably to the family labor input for planting and weeding activities. In the case of weeding for potatoes, this is mainly the application of fungicides to control late blight, which is almost exclusively done by men, but women join to transport water to the fields. It is interesting to note that new technology in potatoes brings in more male labo and thus makes it more a "men's crop."

About 78.2 percent of all nonfamily person-days was provided by the reciprocal exchange of labor with relatives or neighbors or both, 17.8 percent was wage labor paid in cash, 2.1 percent was wage labor with payment in kind, and only 1.9 percent was in the form of nonreciprocal exchange of labor (Table 17).

Differences exist by crop, activity, and type of nonfamily labor. The employment of nonfamily labor is activity-specific and, except for peas and beans, is concentrated on soil preparation, ranging from 40.3 percent of all nonfamily labor for cultivation in maize to 49.6 percent in the case of sweet potatoes. A substantial contribution of cash labor was found for preparing soil for maize, sorghum, and potatoes, and for weeding and harvesting potatoes. The reciprocal exchange of labor is most important during planting and harvesting of crops.

### Land Shortage and Labor Use in Agriculture

Both family and total labor input per hectare were substantially higher for the smallest farm-size group than for the largest (Table 18). The share of men in total family

## Table 16—Distribution of family labor input by sex and age groups and by activities for different crops, 1985/86

| Crop/Activity | Share of Total Family Labor Input | Share of Total Family Labor Input | | |
|---|---|---|---|---|
| | | Men | Women | Children[a] |
| | | (percent) | | |
| Maize | | | | |
| Cultivating | 30.1 | 39.0 | 61.0 | 0.0 |
| Planting | 12.5 | 5.5 | 93.7 | 0.8 |
| Weeding | 40.2 | 1.6 | 97.8 | 0.6 |
| Harvesting | 17.0 | 34.2 | 65.0 | 0.8 |
| Other | 0.2 | 0.0 | 100.0 | 0.0 |
| Total | 100.0 | ... | ... | ... |
| Sorghum | | | | |
| Cultivating | 34.0 | 45.8 | 54.2 | 0.0 |
| Planting | 13.7 | 26.5 | 72.2 | 1.3 |
| Weeding | 36.5 | 2.9 | 96.2 | 0.9 |
| Harvesting | 15.2 | 40.2 | 58.7 | 1.1 |
| Other | 0.6 | 0.0 | 100.0 | 0.0 |
| Total | 100.0 | ... | ... | ... |
| Potatoes | | | | |
| Cultivating | 31.2 | 45.4 | 53.5 | 1.1 |
| Planting | 16.4 | 37.2 | 62.7 | 0.1 |
| Weeding | 25.7 | 41.3 | 58.4 | 0.3 |
| Harvesting | 26.7 | 40.4 | 59.3 | 0.3 |
| Other | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 100.0 | ... | ... | ... |
| Sweet potatoes | | | | |
| Cultivating | 39.1 | 35.0 | 65.0 | 0.0 |
| Planting | 27.9 | 4.1 | 95.8 | 0.1 |
| Weeding | 32.8 | 0.7 | 98.7 | 0.4 |
| Other | 0.2 | 0.0 | 100.0 | 0.0 |
| Total | 100.0 | ... | ... | ... |
| Peas and beans | | | | |
| Cultivating | 20.5 | 29.1 | 70.1 | 0.8 |
| Planting | 5.7 | 0.0 | 100.0 | 0.0 |
| Weeding | 13.6 | 0.0 | 99.7 | 0.3 |
| Harvesting | 31.4 | 33.8 | 65.0 | 1.2 |
| Other | 28.8 | 42.2 | 57.3 | 0.5 |
| Total | 100.0 | ... | ... | ... |
| Total family labor | 100.0 | 25.3 | 74.1 | 0.6 |

Source: International Food Policy Research Institute survey subsample, 1985/86.

Note: Labor allocation to crops in mixed cultivation was identified in the plot-specific surveys by taking account of the share of the respective crop in the plot's output as far as activities applicable to the joint crops are concerned (for example, weeding).

[a] Both male and female below 15 years of age.

labor input was lower for the smallest farm-size group (22 versus 29 percent). When taking the share of the wife of the household head instead of all female family members above 15 years of age, the differences between both groups were even more pronounced, with the wife of the household head providing 74 percent of the total family labor in the smallest farm-size group, against 63 percent in the largest. This pattern of a decreasing women's share in agricultural family labor with rising farm size is found in many

## Table 17—Distribution of total nonfamily labor input and type of nonfamily labor, by activities for different crops, 1985/86

| Crop/Activity | Share of Total Nonfamily Labor Input | Type of Nonfamily Labor as Share of Total Labor Input | | | |
|---|---|---|---|---|---|
| | | Cash | In Kind | Reciprocal Exchange | Nonreciprocal Exchange |
| | | | (percent) | | |
| Maize | | | | | |
| Cultivating | 40.3 | 58.1 | 2.5 | 37.5 | 1.9 |
| Planting | 13.3 | 17.0 | 0.0 | 81.1 | 1.9 |
| Weeding | 23.9 | 21.1 | 6.3 | 64.2 | 8.4 |
| Harvesting | 22.5 | 0.0 | 0.0 | 96.6 | 3.4 |
| Other | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 100.0 | ... | ... | ... | ... |
| Sorghum | | | | | |
| Cultivating | 45.4 | 45.7 | 0.0 | 53.8 | 0.5 |
| Planting | 10.7 | 14.9 | 0.0 | 85.1 | 0.0 |
| Weeding | 21.4 | 12.8 | 14.9 | 69.1 | 3.2 |
| Harvesting | 21.8 | 0.0 | 0.0 | 100.0 | 0.0 |
| Other | 0.7 | 0.0 | 0.0 | 100.0 | 0.0 |
| Total | 100.0 | ... | ... | ... | ... |
| Potatoes | | | | | |
| Cultivating | 43.6 | 68.6 | 3.2 | 28.2 | 0.0 |
| Planting | 8.2 | 2.9 | 0.0 | 97.1 | 0.0 |
| Weeding | 12.5 | 25.9 | 0.0 | 68.5 | 5.6 |
| Harvesting | 35.7 | 31.2 | 0.0 | 67.5 | 1.3 |
| Other | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 100.0 | ... | ... | ... | ... |
| Sweet potatoes | | | | | |
| Cultivating | 49.6 | 17.4 | 3.6 | 76.1 | 2.9 |
| Planting | 18.3 | 0.0 | 0.0 | 100.0 | 0.0 |
| Weeding | 32.1 | 0.0 | 3.4 | 96.6 | 0.0 |
| Other | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 100.0 | ... | ... | ... | ... |
| Peas and beans | | | | | |
| Cultivating | 10.9 | 20.7 | 6.9 | 72.4 | 0.0 |
| Planting | 0.9 | 0.0 | 0.0 | 100.0 | 0.0 |
| Weeding | 4.9 | 7.7 | 0.0 | 92.3 | 0.0 |
| Harvesting | 50.8 | 0.0 | 0.0 | 100.0 | 0.0 |
| Other | 32.5 | 27.9 | 2.3 | 69.8 | 0.0 |
| Total | 100.0 | ... | ... | ... | ... |
| Total nonfamily labor | 100.0 | 17.8 | 2.1 | 78.2 | 1.9 |

Source: International Food Policy Research Institute survey subsample, 1985/86.

developing countries. However, in this case, the relative decrease goes along with an absolute increase in women's agricultural work: the wife of the household head spent 87.6 days in the smallest versus 112 days in the largest farm-size group.

## Productivity in Agriculture

Farmers in this study, like subsistence-oriented farmers anywhere else, are exposed to a risky production and market environment, and thus consider numerous factors when deciding what to grow and what not to grow. A quantitative assessment of these

**Table 18—Family and total labor input for different crops and farm-size quartiles, 1985/86**

| Crop | Bottom Quartile |  | Top Quartile |  |
|---|---|---|---|---|
|  | Family Labor | Total Labor | Family Labor | Total Labor |
|  | (person-days/hectare) |  |  |  |
| Maize | 308* | 377* | 153 | 220 |
| Sorghum | 321 | 426 | 242 | 347 |
| Potatoes | 511* | 624* | 174 | 264 |
| Sweet potatoes | 376 | 407 | 311 | 413 |
| Peas | 90 | 104 | 107 | 133 |
| Beans | 434 | 515 | 284 | 318 |
| Total average per hectare | 274 | 342 | 131 | 213 |

Source: International Food Policy Research Institute survey subsample, 1985/86.

Notes: Data are derived from total farm size, including Gishwati land.

*Significant at the 0.10 level.

determinants in the context of productivity computations at the farm level for the various crops is complicated by numerous factors in this specific case. Among these are the difficulty of quantifying inputs and outputs, field measurements, and the multitude of crop combinations in mixed cropping systems. These technical factors are one aspect of the problem. Another relates to the integration of subsistence production with production for the market and the important role of nonagricultural income earnings. This complex decisionmaking process is influenced not only by short-term profit maximization objectives in crop production, but also by the expectations regarding crop and labor markets and related risks that largely determine household-level food security.

## Why They Grow What They Grow

Male and female members of the farm families in the survey were asked a set of questions concerning their reasons for growing or not growing the major crops generally found in the area. This survey of the stated reasons covers the production year 1985/86. The set of reasons given as options was a result of extensive survey pretesting. For eight major crops, farmers who were actually growing a particular crop were asked to indicate on a scale of 1 (very important) to 3 (not important) why they grew it (Table 19). Similarly, farmers who did not grow the crop were asked to indicate by the same scale of importance their reasons for not growing it.

Top priority for all food crops is indicated by the answer "We want to consume it, that's why we grow it." An exception is potato production in the Gishwati fields, which shows a mix of "grown for cash" and "grown for consumption." Labor considerations are of major importance for sweet potatoes and peas. Technical reasons are of substantial importance for growing or not growing a crop, as indicated by the values close to or below 2.0 in the respective second questions of Table 19—"fits (or does not fit) well to our fields."

Tea and tobacco are grown because of the desire to sell for cash. Similarly, those who choose not to grow them do so because they consider these crops either as "not selling well," in the case of tea, or requiring a substantial amount of labor in relation to the potential returns per labor input. In the case of potatoes grown in Gishwati fields, farmers who

## Table 19—Stated reasons for growing or not growing a particular crop, 1985/86

| Stated Reason | Potatoes | Gishwati Potatoes | Sweet Potatoes | Maize | Sorghum | Beans | Peas | Tea | Tobacco |
|---|---|---|---|---|---|---|---|---|---|
| | (value of indication)[a] | | | | | | | | |
| Reasons for growing the crop (farmers who grew it in 1985/86) | | | | | | | | | |
| 1. We want to eat/consume it | 1.0 | 1.7 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | ... | 2.6 |
| 2. Fits well to our fields | 2.1 | 1.8 | 2.0 | 2.1 | 2.0 | 2.3 | 2.1 | 2.3 | 2.1 |
| 3. We want to sell it for cash | 2.7 | 1.5 | 2.5 | 2.7 | 2.2 | 2.8 | 2.6 | 1.2 | 1.1 |
| 4. The crop stores well | 2.4 | 2.6 | 2.9 | 2.3 | 2.1 | 2.4 | 2.4 | 2.6 | 2.5 |
| 5. It is our custom to grow it | 2.0 | 2.6 | 2.0 | 2.0 | 2.0 | 2.1 | 2.0 | 2.5 | 2.3 |
| 6. The crop always works out well; it is not risky | 2.2 | 2.0 | 2.2 | 2.3 | 2.4 | 2.7 | 2.2 | 2.3 | 2.3 |
| 7. Does not cost much to grow | 2.4 | 2.8 | 2.3 | 2.6 | 2.6 | 2.5 | 2.2 | 2.5 | 2.6 |
| 8. Does not require much work | 2.4 | 2.9 | 1.9 | 2.7 | 2.9 | 2.5 | 1.9 | 2.9 | 3.0 |
| (Number of observations) | (146) | (85) | (155) | (188) | (146) | (185) | (117) | (36) | (22) |
| Reasons for not growing the crop (farmers who did not grow it in 1985/86) | | | | | | | | | |
| 1. We do not want to consume it | 3.0 | 3.0 | 3.0 | b | 3.0 | b | 2.8 | ... | 2.5 |
| 2. Our fields are not good for the crop | 2.0 | 2.9 | 1.9 | ... | 1.9 | ... | 2.2 | 2.4 | 2.4 |
| 3. Does not sell well | 3.0 | 2.9 | 2.8 | ... | 3.0 | ... | 2.9 | 2.2 | 3.0 |
| 4. Does not store well | 3.0 | 3.0 | 2.4 | ... | 2.9 | ... | 3.0 | 2.9 | 2.9 |
| 5. We customarily do not grow it | 2.7 | 2.5 | 2.3 | ... | 2.4 | ... | 2.5 | 2.5 | 2.4 |
| 6. There are frequent troubles with the crop | 2.3 | 2.7 | 2.8 | ... | 2.5 | ... | 2.6 | 2.7 | 2.9 |
| 7. Costs too much to grow | 2.6 | 2.3 | 3.0 | ... | 2.9 | ... | 2.7 | 2.3 | 2.5 |
| 8. Requires a lot of work | 2.9 | 2.1 | 3.0 | ... | 2.9 | ... | 2.8 | 1.8 | 2.0 |
| (Number of observations) | (43) | (21)[c] | (34) | b | (43) | b | (69) | (147) | (164) |

Source: International Food Policy Research Institute survey, 1985/86.

[a] The mean values of indication are 1, very important; 2, important; 3, not important.

[b] Less than five observations.

[c] Only farmers who had access to a Gishwati field are included.

do not grow potatoes there mentioned as their second most important reason the high production costs. This is in line with the finding that the smallest farmers and lower-income farmers do not join in the Gishwati potato production to the same extent as larger farmers, who are less constrained by cash for input financing.

The risks that pertain to certain crops—especially potatoes—are considered by a number of farmers to be an important reason for not growing them, but riskiness or nonriskiness of crops does not show up as very important in the average figures presented in Table 19. Specific farm conditions are of major importance for production efficiency, and crop risks rank high among those at the specific production location, yet this concern is leveled out in the average figures presented. The impact of perceived risk on the degree of subsistence will be further discussed in the context of a multivariate regression analysis in Chapter 6.

In the next section, detailed farm- and crop-specific information is provided for the assessment of returns to land and labor by major subsistence crops. Following that, the more aggregate picture of labor productivity in this complex farming system is addressed, making use of econometric analysis.

### Productivity of Major Crops: Gross Margins

The cropping systems prevailing in the study area are extremely labor-intensive, at least when compared with other African countries where farmers grow the same crops. Table 20 summarizes, based on the subsample data, the total labor input per hectare and the land and labor productivities of the various cropping systems. It further shows the respective gross revenues and gross margins per unit of land and labor. Unfortunately, there are no comparable labor input data available for Rwandan smallholder agriculture based on survey information for this zone.

By far the highest labor input was found for the cultivation of potatoes in the Gishwati area, with 622 person-days per hectare and season. From the sample data, it was impossible to exclude the amount of labor necessary for clearing the former forest vegetation when farmers cultivated potatoes for the first time, so the total amount of 622 person-days may be somewhat overestimated.

The total labor input for other food crops varies considerably—261 person-days for maize in sole stands and under mixed cropping, approximately 400 person-days for sweet potatoes, but only 102 person-days for peas, which are grown with a traditional cropping technique that requires no deep soil preparation or weeding. The coefficients of variation indicate that, within the various cropping systems, labor input and yields do not vary substantially. It should be noted that the different crops considered in Table 20 are on the field for different lengths of time.

Food-energy production per unit of land, measured in calories[8] per hectare, is highest for potatoes and sweet potatoes, with approximately 5.5 million calories each, followed by maize and sorghum under mixed cropping and maize in sole stands. However, when comparing the relatively low energy output of beans and peas in particular, it has to be kept in mind that both crops (and potatoes, too) can be cultivated twice a year, while only one crop per year is possible for maize and sorghum.

In terms of gross margins per hectare, potatoes rank first with FRw 37,688 (US$419), followed by sweet potatoes and beans with approximately FRw 25,000 (US$280) each.

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[8] All calories referred to in this report are kilocalories.

### Table 20—Average land and labor productivity of different cropping systems, subsample households, 1985/86

| Item | Maize (Sole Stands) | Maize (Mixed Stands)[a] | Sorghum (Mixed Stands) | Beans (Sole Stands) | Peas (Sole Stands) | Sweet Potatoes (Sole Stands) | Potatoes (Sole Stands) | Tea (Small-holder)[b] |
|---|---|---|---|---|---|---|---|---|
| Total labor input | | | | | | | | |
| (person-days/hectare)[c] | 261.6 | 260.5 | 346.9 | 315.1 | 101.5 | 398.0 | 621.8 | 470.0 |
| | (0.42) | (0.38) | (0.64) | (0.24) | (0.56) | (0.63) | (0.78) | (0.40) |
| Yield (kilograms/hectare)[c] | 1,037 | ... | ... | 874.6 | 476.1 | 5,055 | 9,615 | 2,692 |
| | (0.45) | | | (0.50) | (0.55) | (0.42) | (0.87) | (0.49) |
| Yield (1,000 calories/hectare) | 3,383 | 3,789 | 3,649 | 2,655 | 1,488 | 5,472 | 5,526 | ... |
| Gross revenues | | | | | | | | |
| (FRw/hectare) | 14,518 | 25,222 | 20,361 | 26,238 | 14,283 | 25,275 | 57,688 | 29,622 |
| (US$/hectare) | 161 | 281 | 226 | 292 | 159 | 281 | 642 | 329 |
| Variable costs: (seeds; fungicides for potatoes only) | | | | | | | | |
| (FRw/hectare) | 625 | 11,375 | 6,775 | 1,500 | 1,500 | 0 | 20,000 | 8,805 |
| (US$/hectare) | 7 | 127 | 75 | 17 | 17 | 0 | 222 | 98 |
| Gross margin | | | | | | | | |
| (FRw/hectare) | 13,893 | 13,847 | 13,586 | 24,738 | 12,783 | 25,275 | 37,688 | 20,817 |
| (US$/hectare) | 155 | 154 | 151 | 275 | 142 | 281 | 419 | 232 |
| Labor productivity (calories/person-day) | 12.9 | 14.6 | 10.5 | 8.4 | 14.7 | 13.7 | 8.9 | ... |
| Gross margin | | | | | | | | |
| (FRw/person-day) | 53.1 | 53.2 | 39.2 | 78.5 | 125.9 | 63.5 | 60.6 | 58.3 |
| (US$/person-day) | 0.62 | 0.59 | 0.44 | 0.87 | 1.40 | 0.71 | 0.67 | 0.65 |
| Number of observations | 21 | 24 | 19 | 18 | 35 | 6 | 18 | 12 |

Source: International Food Policy Research Institute survey subsample, 1985/86.

Note: US$1.00 = FRw 89.90 (1986 exchange rate; average for January-August).

[a] Most frequently maize, beans, and potatoes.

[b] Average for 1985/86 (annual).

[c] Figures in parentheses are coefficients of variation.

The gross margins per hectare are almost identical for both maize cropping systems and sorghum; peas rank last with FRw 12,783 (US$142) per hectare and season.

However, in terms of labor productivity, the ranking changes. Here, the food-energy production per person-day is highest for peas and maize under mixed cropping, with about 14.7 calories per person-day each, and sweet potatoes, with 13.7 calories; beans and potatoes rank lowest, while sorghum and maize (both in sole stands) are in the middle range.

Peas are by far the most profitable crop, with FRw 126 (US$1.40) per person-day, which is more than three times the labor productivity of sorghum in mixed stands and approximately twice as high as the returns to labor for sweet potatoes (FRw 63.5 per person-day, or US$0.71), potatoes (FRw 60.6), and tea (FRw 58.3). For both maize cropping systems, the returns to labor are almost the same, about FRw 53.0. Hardly any crop production reaches labor productivity levels close to the official minimum wage rate, which was FRw 100 per day during the survey period.

The highest variable production costs of FRw 20,000 per hectare and season occur for potato cultivation,[9] followed by maize in the mixed cropping system (FRw 11,375), tea (FRw 8,805), and sorghum (FRw 6,775). In the case of sweet potatoes, no variable costs appear because farmers usually provide their own planting material or get it free from neighbors or relatives. At least, no regular market of sweet potato stalks could be observed.

## Aggregate Production Relationships

Production relationships in the agricultural system are fairly complex. The interactions between components of the system, especially the complementarity between factors of production—land, labor, and capital—and how they relate to aggregate output, could not be captured by the crop-specific analysis. Following the conceptual framework in Chapter 4, the aggregate production relationships are evaluated here. First, an aggregated all-crops production function of the Cobb-Douglas type is estimated and discussed—corresponding to equation (5) in Chapter 4—and, second, an attempt is made to explain differences in labor productivity in agriculture of the sample households in order to trace determinants and effects of agricultural change. These two production analyses are done here in parallel because of the inherent weaknesses of production function analyses based on cross-sectional information. Assessing relationships from two different angles at different levels of aggregation will help in determining ranges of basic relationships and determinants—that is, of labor productivity.

Generally, some caution should be used when interpreting the estimation results from Cobb-Douglas production functions of the nature presented here (see, for instance, Upton 1987 and Dillon 1977). First, the standard specification used involves absolute output in relation to a size variable. Second, some underlying variables may affect both input and output levels (for example, management skills). Also location-specific factors come into play in this context (a soil-quality variable is included in the model used here, as an attempt to capture this aspect). These weaknesses should be kept in mind when drawing conclusions from the analysis.

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[9] Based on information provided by the GBK project office and D. Haverkort of the *Centre international de la pomme de terre/Programme national pour l'amélioration de la pomme de terre* (CIP/PNAP) (1985).

Results of the Cobb-Douglas production function estimates are presented in Table 21. It should be noted that the labor and the capital variables are rough approximations of the actual labor input and capital for agricultural production only (see variable descriptions at the bottom of Table 21).[10] The results of the econometric estimation show the dominant role of land for total production in agriculture in this land-scarce environment. According to the model results, the production elasticity of land is 0.53—that is, a 10 percent increase in availability of land for a farm household increases total output, other things holding constant, by 5.3 percent.

The production elasticity of labor is 0.22. This low level is not surprising given the excess availability of labor and the shortage of land. More surprising is the fairly high production elasticity of capital at 0.19. Whether or not this indicates underinvestment in capital for agricultural production cannot be explored here. Average capital stock per farm for crop production was computed at FRw 1,181 (US$13.14).

In this context, it should be remembered that the introduction of capital inputs into a production function raises many problems because lag structures between use of capital inputs and output response are complex and capital investments may be lumpy or indivisible, so a smooth mathematical function provides only for a rough description of the response. Cautious interpretation is therefore called for. This general problem also translates into limitations of deriving scale effects from the Cobb-Douglas function estimate as is usually done. In principle, adding up the production elasticities of the three key factors of production (LAND, LABOR, CAPITAL) gives a rough indication of the

**Table 21—Aggregate agricultural production function estimates**

| | Exogenous Variables[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LAND | LANDQ | LABOR | CAPITAL | Constant | $R^2$ | F | Degrees of Freedom |
| Parameter | 0.5257 | -0.1911 | 0.2202 | 0.1917 | 7.560 | 0.506 | 48.9 | 183 |
| t-value | (8.87) | (-2.18) | (2.14) | (3.19) | | | | |
| Mean value of variable | -0.56 | 1.70 | 6.05 | 6.76 | ... | ... | ... | ... |
| Standard deviation | 0.71 | 0.41 | 0.40 | 0.68 | ... | ... | ... | ... |

Note: The dependent variable is AGPROD = logarithm of total value of 1985/86 agricultural production in FRw.

[a]Definitions of variables:
LAND = logarithm of farm size in hectares.
LANDQ = land-quality index; based on subjective evaluation by farmer on field-by-field basis (1=better than average, 2=average, 3=worse than average).
LABOR = logarithm of total available adult labor force for agriculture in days/year (total number of persons above age 15 times days of cropping year minus days of off-farm work, days sick, days absent of individuals, plus hired labor days).
CAPITAL = logarithm of present value of all tools and implements in FRw.

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[10] It may be hypothesized that beyond labor, land and land quality, capital, and also human capital would impinge on farm output. In a different specification, tests were made for the effects of schooling (of household head or wife or both) and of caloric consumption per adult-equivalent (approximating food-energy sufficiency). Both variables were statistically not significant.

nature of economies of scale. This exercise suggests that, as the sum of the production elasticities is 0.93, thus slightly below one, there may be diseconomies of scale given the current production technology in the farming system. While at first glance this may be surprising, given the very small farm size in the area, the mountainous character of the area might indeed explain why larger farm sizes do not lead to reduced costs of production or higher returns per unit of factor input.

Average returns to labor show considerable variance in the overall sample. Table 22 shows a breakdown by three groups of households, arranged according to their level of labor productivity in agriculture, and also presents various household and farm characteristics of these groups in terms of average indicators. A high level of labor productivity found in the top tercile is associated with greater farm size per capita, as expected, better land quality, and a substantially higher use of production capital (monetary value of tools and implements). These joint variations of production factors may hint at potential problems of the Cobb-Douglas production function estimates already discussed in general terms above.

Households with higher labor productivity also have a higher sum of total annual food and nonfood consumption value, which may be viewed as an income proxy. The farm households with the high labor productivity in agriculture are thus richer. Yet, total expenditure per capita in the top productivity tercile is only 7 percent higher than the

## Table 22—Labor productivity in agriculture, by farm and household characteristics, 1985/86

| | Labor Productivity | | | |
|---|---|---|---|---|
| Characteristic | Bottom Tercile | Middle Tercile | Top Tercile | Average |
| Labor productivity (average) (total average = 100)[a] | 35.0 | 78.6 | 182.9 | 100.0 |
| Farmland per capita (hectares) | 0.10 | 0.14 | 0.29 | 0.13 |
| Land-quality index[b] | 1.73 | 1.76 | 1.62 | 1.70 |
| Monetary value of tools and implements (FRw) | 882 | 1,163 | 1,483 | 1,181 |
| Altitude of farm (meters) | 2,306 | 2,316 | 2,345 | 2,322 |
| School years of household head (average) | 0.74 | 0.97 | 0.91 | 0.87 |
| Total annual expenditure/capita (FRw) | 10,732 | 11,306 | 12,225 | 11,432 |
| Calories/adult-equivalent, May 1986 | 2,467 | 2,607 | 2,866 | 2,650 |
| Subsistence consumption (percent of total expenditure) | 46 | 48 | 52 | 48 |
| Household size (persons) | 5.20 | 5.60 | 5.90 | 5.60 |
| Women of working age (percent of all persons of working age) | 51 | 54 | 48 | 51 |
| Children younger than five years (percent of household size) | 25 | 27 | 34 | 29 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] This figure is computed as follows on the basis of available working days for agricultural and home production: agricultural net income 1986/[(persons of working age in household - periods of sickness - family members' time in off-farm work) x working days over periods]. The average labor productivity for all sample farms computed this way over the year was FRw 26 per available working day in 1986.

[b] Better than average = 1; average = 2; worse than average = 3; based on subjective evaluation by farmers on field-by-field basis.

average (while agricultural labor productivity in that group is 83 percent above the average). The gap is closed primarily by off-farm income in households with the smallest farms. In line with the higher income in the top tercile is the finding that these households consume higher levels of food energy per adult-equivalent person. These households also obtain a somewhat higher share of their total consumption value out of own-produced food (52 percent versus 46 percent in the bottom tercile).

In the following, an attempt is made to explain differences in labor productivity in a multivariate analysis. The issue of interest is to explore population density-productivity links. A more rapid population growth, by inducing a greater replacement of equipment, could increase the rate of growth of output (Srinivasan 1988). Boserup (1981) argues that farm technology is influenced by population density in a positive way. In this model, it is hypothesized that labor productivity is determined by availability and quality of land, the capital stock per person, human capital (approximated by schooling of head of household), and the altitude of the farm. Moreover, it is hypothesized that the demographic composition of the household, especially the share of women in the work force, impinges on average labor productivity in agriculture. The detailed specification of the model and the estimation results are presented in Table 23.

Farm size (land) and land quality show a highly significant impact on labor productivity in the expected direction. All other variables show at best an influence of weak statistical significance. Under the current circumstances of increased population growth and little new technology available to farmers, the parameter estimates suggest that a reduction in farm size (at sample mean) by 1.0 percent will reduce labor

**Table 23—Determinants of labor productivity in agriculture**

| Variable[a] | Parameter | t-Value | Mean Value of Variable | Coefficient of Variation |
|---|---|---|---|---|
| LAND | 9.467 | 4.29 | -0.56 | 0.71 |
| CAPITALP | 3.496 | 1.47 | 5.71 | 0.67 |
| LANDQ | -7.162 | -1.96 | 1.70 | 0.41 |
| SCHOOL | -1.189 | -0.80 | 0.87 | 1.04 |
| ALTITUDE | 9.80E-03 | 0.87 | 2,322.00 | 140.00 |
| WSHARE | -4.209 | -0.50 | 0.51 | 0.18 |
| CHILDSH | 14.294 | 1.77 | 0.29 | 0.20 |
| Constant | 1.895 | 0.95 | | |
| $\hat{R}^2$ | .127 | | | |
| F-value | 4.88 | | | |
| Degrees of freedom | 180 | | | |

Note: The dependent variable is net returns per day of family labor available for agricultural and home goods production.

[a]Definitions of variables:

LAND = logarithm of farm size in hectares.
CAPITALP = logarithm of present value of all tools and implements in FRw per adult person.
LANDQ = land-quality index (area weighted, 1=best, 3=worst).
SCHOOL = years of schooling of head of household.
ALTITUDE = altitude of farm in meters.
WSHARE = share of women of working age in total number of persons of working age in the household.
CHILDSH = share of children under five years in total number of persons in the household.

productivity by 0.36 percent. This finding is consistent with the results presented at the outset of this chapter indicating that labor productivity declines less than proportionally as farm size decreases (Table 11), which is in line with Boserup 1981 and, more recently—with specific reference to Africa—with Binswanger and Pingali 1987. From this elasticity of 0.36 of labor productivity with respect to farm size, the following may be extrapolated: if reduction in farm size continues at the rate of current population growth (about 4.0 percent in the study area), new "exogenous" agricultural production technologies would "only" have to contribute an incremental 36.0 percent of this rate (that is, 1.4 percent a year) in order to at least maintain current levels of labor productivity in agriculture. Induced indigenous techniques toward increased labor productivity—"Boserup effects"—would cover the rest as holdings get smaller. This would include an increased labor input per hectare and changes in land-use patterns. As pointed out by Salehi-Isfahani (1988), these Boserup effects are a description of endogenous technology rather than of behavior.

Still, a rate of technological change shifting labor productivity by 1.4 percent a year (on top of the expected 2.6 percent indigenous effect) is quite high and requires major efforts in research and input supply policy. Thus, the induced indigenous technical progress without explicit policies for technical change would be too slow to maintain current levels of labor productivity and could thereby result in increased poverty and lack of entitlements to food for the poor. Also, it needs to be stressed that the relationship between labor productivity and person-land ratio in the context of fragmentation cannot, of course, be extrapolated for long into the future, and the stated quantitative results apply only to the range of size patterns in the sample. (This issue is taken up in more detail in the long-term simulations in Chapter 8.)

Lipton (1990) points out that the success of population-driven processes (such as increased effective demand for technology) that enhance poor people's entitlement to food may depend on how swiftly they complete the demographic transition to lower birthrates. Assistance in achieving a swift transition becomes of critical importance in Rwanda, which at the national level still shows population growth rates of about 3.4 percent a year in the late 1980s with no indication of fast decline.

## Off-Farm Employment

Off-farm employment was identified above as a key factor in rural diversification and commercialization (Chapter 3). Although agriculture is the main employer in the study area, the cash economy is largely consigned to the off-farm labor market. Improved understanding of the rural labor market is essential for an employment-oriented development strategy. Rapid expansion of the off-farm employment opportunities along with yield-increasing technological change in agriculture are the prerequisites for assured entitlements to food for the poor in this densely populated region.

Off-farm work, however, is to a substantial extent closely linked to agricultural production. In fact, forward and backward linkages of the agricultural sector are not negligible either. As will be seen, new commercial agriculture in the case of tea, and rural infrastructure investments related to agricultural development programs in the area are employers of major importance.

Quite differently from agricultural production for the market and particularly from food production for subsistence, which largely employs a female work force, off-farm work is largely a man's affair. Female off-farm employment is significant only for the younger age groups; in fact, girls under 16 work more off-farm than boys of the same age group (Table 24). This changes, however, in the 16-24 age group, and above the age of 25, female off-farm employment is almost negligible. Men in the 25-54 age group work, on average, five to about eight days a month off-farm.

## Dominant Role of Projects and Agroindustries

Off-farm employment of farm households fluctuates considerably within a year and over the years. Male off-farm employment in the 25-54 age group was down by 40 percent during the summer of 1986 compared with the earlier part of 1986 (Table 24). Month-to-month fluctuations of aggregate off-farm employment are also considerable and to a large extent are due to the seasonality of employment offered by the major local agroindustries and agricultural development programs in the region (Figure 5). The labor demand in the tea sector, for instance, peaks in April and August. This demand is of a fairly regular seasonal nature. The employment offered by the World Bank GBK scheme—the reforestation and livestock project in the Gishwati forest—represents another type of irregular labor demand. The scheme employed a work force of 7,000 at its peak in 1984 (February-May).[11] That employment was down to 3,500 in June-August 1986, and in September 1986 another 3,000 workers were laid off, bringing the work force to about 500. These changes are reflected in the sample households. The share of employment provided by that scheme dominated the off-farm employment in November 1985 but became negligible in August 1986 (Figure 5).

The central role of projects for employment is also reflected in the structure of employment in the rural labor market, as presented in Table 25: public development projects, such as the GBK scheme, the German IPV project, and the government road construction project, covered about one-third of total off-farm employment in 1985 but only one-fifth in 1986. Nearly 30 percent of off-farm employment in 1986 was generated by the tea factories in the area, which are, at least seasonally, substantial employers of the female labor force working off-farm. Children under 16 also work to a significant extent for these employers.

Paid daily agricultural work is of minor importance and only for households with a very limited land base (Table 26). The structure of off-farm work changes significantly with farm size. Employment in the tea factories is most important for the smaller farm

**Table 24—Off-farm work by age and sex in different time periods, 1985/86**

| | Average Workdays per Month | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 11-15 Years | | 16-24 Years | | 25-54 Years | | Above 54 Years | |
| Time Period | Male | Female | Male | Female | Male | Female | Male | Female |
| 1985 | 0.3 | 1.0 | 2.8 | 1.6 | 7.8 | 0.1 | 2.3 | ... |
| January-April 1986 | ... | 1.3 | 3.0 | 1.2 | 8.4 | ... | 1.8 | ... |
| June-September 1986 | 0.6 | 0.2 | 2.4 | 0.3 | 5.0 | 0.2 | 1.8 | 0.1 |

Source: International Food Policy Research Institute survey, 1985/86.

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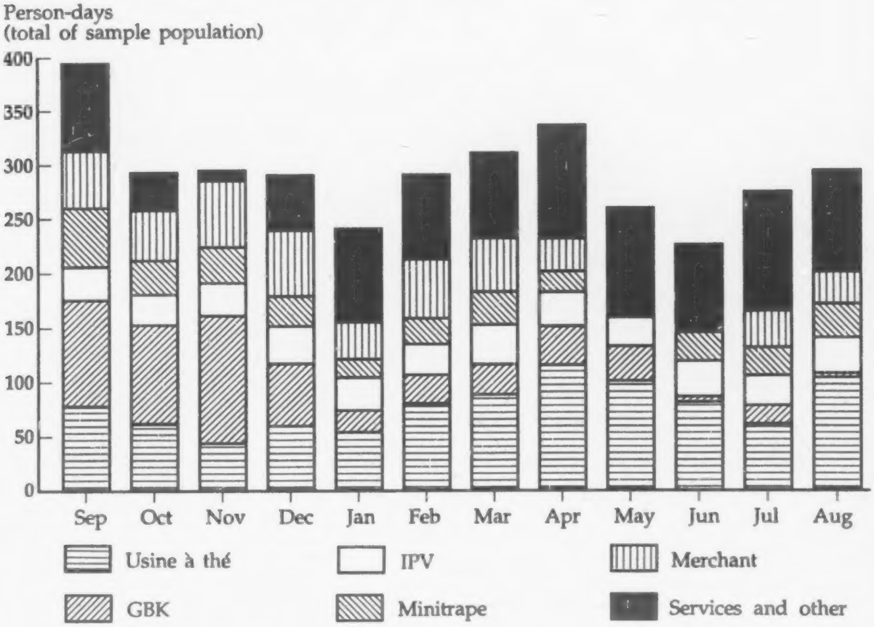
[11] Information provided by the local GBK project office (1986).

**Figure 5—Seasonal distribution of off-farm labor, by kind of occupation**



Notes: GBK = World Bank project in Gishwati forest (reforestation, infrastructure).
IPV = German agricultural development project.
Minitrape = government road construction program.
Usine à thé = tea factory including factory tea gardens.

**Table 25—Off-farm work by type of employment for men, women, and children, 1985 and 1986**

| Type of Employment | Family Shares of Off-Farm Work, 1985 | | | | Family Shares of Off-Farm Work, 1986[a] | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | Men | Women | Children under 16 | Total | Men | Women | Children under 16 |
| | | | | (percent) | | | | |
| Paid agricultural daily work | 3.6 | 77 | 12 | 11 | 2.3 | 82 | 14 | 4 |
| Public projects | 32.1 | 92 | 8 | ... | 20.9 | 97 | 3 | ... |
| Tea factory | 17.9 | 64 | 19 | 17 | 30.2 | 84 | 8 | 8 |
| Handicrafts | 17.9 | 100 | ... | ... | 11.6 | 98 | ... | 2 |
| Other | 28.6 | 87 | 9 | 4 | 34.9 | 88 | 7 | 5 |
| Total | 100.0 | 86 | 9 | 5 | 100.0 | 89 | 6 | 5 |

Source: International Food Policy Research Institute survey, 1985/86.

[a]Only through September.

Table 26 —Off-farm work of men, women, and children, by type of employment and farm-size quartiles, 1986

| Type of Employment | Farm Size<br>Smallest Quartile | <br>Second Quartile | <br>Third Quartile | <br>Largest Quartile |
|---|---|---|---|---|
| | (percent) | | | |
| Paid agricultural daily work | 11.1 | 1.5 | ... | ... |
| Public projects | 20.0 | 6.0 | 25.7 | 28.5 |
| Tea factories | 33.3 | 47.8 | 14.3 | 13.0 |
| Handicrafts | 17.8 | 16.4 | 17.1 | 13.0 |
| Other | 17.8 | 28.4 | 42.9 | 45.6 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

Source: International Food Policy Research Institute survey, 1985/86.

households; from one-third to nearly one-half of off-farm employment in the two smallest farm-size classes is in these factories. In the larger farm-size classes only very little work time is allocated to the tea factories. For the households with a larger land base, off-farm work in public projects and other work (which includes self-employment and merchant activities) plays a major role. In general, these are jobs with higher wage rates. The result that members of households with larger farms tend to be found in higher-paying jobs may be explained by higher returns to farm labor (opportunity costs) in the larger farm-size groups.

### Household-Level Determinants of Off-Farm Work

Obviously, a number of interacting factors determine the total amount of off-farm work time spent by the households: among these are the opportunity costs of time spent away from the own farm, the off-farm wage rate, certain human capital characteristics, and the demographic characteristics of the household. An attempt is made in the following to explain the allocation of work time to off-farm work in a regression model corresponding to equation (6) in the concept described in Chapter 4. The dependent variable in the model is the days of off-farm work per household during the survey period in 1986. It was hypothesized that increased returns to labor on the own farm reduces time allocated to off-farm work. The opposite is expected from a rising wage rate offered in the off-farm labor market. From a larger work force in the household, an increased allocation of time is to be expected for off-farm work, but—because of the rigidities of the off-farm labor market by gender—not if the share of women in the work force is increased. The estimation results of the model are presented in Table 27.

The model results in Table 27 show that increased labor productivity in agriculture significantly reduces off-farm labor supply by the households as expected. A 10 percent increase in agricultural labor productivity reduces off-farm work time by the households by 2.6 percent. This suggests that agricultural technology that increases labor productivity would significantly reduce the pressure on the off-farm labor market and thereby probably have favorable wage rate and employment effects for the growing landless population.

An increased wage rate in the off-farm labor market works in the opposite direction, but the parameter estimate is not statistically significant. This is not too surprising, given the rigidities in the labor market in which formal employment in public projects with

Table 27—Regression analysis of allocation of work time to off-farm work

| Explanatory Variable[a] | Parameter | t-Value | Mean of Variable | Standard Deviation |
|---|---|---|---|---|
| AGRLABP | -0.5746 | -2.39 | 27.58 | 21.02 |
| WAGE | 0.0667 | 1.00 | 142.20 | 77.05 |
| WSHARE | -84.3640 | -2.96 | 0.51 | 0.18 |
| PERSWORK | 18.2594 | 5.61 | 3.19 | 1.56 |
| Constant | 47.5620 | 1.98 | | |
| $\hat{R}^2$ | 0.21 | | | |
| F-value | 12.04 | | | |
| Degrees of freedom | 182 | | | |

Note: The dependent variable is OFFWORK = days of off-farm work per household (1986, January-September)

[a] Definitions of variables:

AGRLABP = net returns in agriculture per available labor day (in FRw; labor days available as defined in agricultural labor productivity model, Table 23).
WAGE = off-farm wage rate per day (in FRw).
WSHARE = share of women in household among adults.
PERSWORK = adult persons in household.

fixed wage rates coexists with a free labor market in which minimum wages are hardly enforced. As the model captures neither this nor dynamic changes and risks in the alternative employment categories, the wage effect is not strong.

As expected, larger households send more persons into the off-farm labor market, but less so if women hold an increased share in the household work force (see variables WSHARE and PERSWORK in Table 27).

## Summary of Findings

Commercialization of the rural economy in this setting is driven by rapid population growth, which increasingly puts pressure on the nonagricultural rural labor market.

The commercialization process at this location is broad-based and is not the effect of a single specific project or program activity. The agricultural commercialization process is partly driven by opening up new lands for potato production and by the introduction of tea cultivation and tea processing. For low-income households, however, both of these processes are less important than endogenous commercialization through home manufacturing of sorghum beer. Rural development programs of various types play an important role in the overall commercialization process. They do, however, represent a substantial instability in the nonagricultural rural labor market.

Women are the key labor force in agriculture, providing about 70 percent of labor input. Their participation in the new cash crop production (potatoes as a modern input) is, however, relatively reduced as compared with staple food production. Introduction of accelerated technological change in cash crops and subsistence food crops has to focus on women farmers in order to have broad outreach and impact.

Subsistence orientation of agriculture remains the major focus of the farm population. Increased person-land ratios, which will continue to rise because of rapid population growth, will further reduce market integration of agriculture if the market environment does not become less risky and if off-farm employment opportunities do not increase.

In a situation of low levels of labor productivity and low employment growth in agriculture, labor is increasingly pushed into off-farm low-productivity employment. Diversification of income sources as a mechanism to cope with risk in both sectors is adopted by households. Increased labor productivity in agriculture induced by technological change would provide better employment possibilities for the growing landless rural population.

While endogenous rates of technological change are found to be high and significant, the incremental technological change required to be introduced by research, extension, and input provisions beyond current levels would have to be at least 1.4 percent a year just to maintain the current low levels of labor productivity in agriculture. Reasonably high levels of production elasticities of capital in agriculture suggest increased emphasis on rural financial institutions to support rapid technological change in the smallholder agricultural sector.

# 6

# CONSUMPTION RELATIONSHIPS AND EFFECTS OF COMMERCIALIZATION

Hypotheses explored in this chapter relate to the effects of commercialization on food consumption. First, basic relationships between income and expenditure and between income and food-energy consumption relationships are analyzed. The authors then focus specifically on the hypotheses that income from cash crops and male-controlled cash income alters spending on food consumption.

## Food from Own Production and Food and Nonfood Purchases

Rural households in Rwanda spend most of their available resources on food, whether own-farm production resources or earned cash income converted to food. Fifty-eight percent of average total household expenditures (including the value of food produced for own consumption) are spent on basic food items, such as pulses, cereals, roots, and tubers. The overall spending on food by households—that is, the share of total expenditures—does not change very substantially across expenditure classes in the sample, which can be attributed to the generally low level of income. About 60 percent of the value of all food and beverage consumption is represented by the households' own-produced food. This is somewhat less in the top expenditure quartile.

The pattern of expenditures on nonfood in relative terms shows little change among the bottom three quartiles, but some change in the top expenditure quartile toward a higher propensity for spending on housing and celebrations and luxuries (Table 28). The more detailed data presented in Table 29 also suggest that with increased income above a certain level—that is, in the third and top expenditure quartiles—more is spent for health care.

Some interesting patterns are visible when expenditures for food are disaggregated (Table 29). Sweet potatoes show up as the staple food of the poor, representing 12 percent of all consumption expenditures in the bottom quartile but less than 5 percent in the top quartile. On the other hand, very high income elasticities indicated by a simple approximation are found for sorghum (4.73), new cereals (such as wheat and rice, which dominate in commodity group 6, 2.96), bottled beer and soft drinks (3.86), animal products (4.29), and sugar (3.17). The low income elasticity of maize (0.48) compared with sorghum is also noteworthy. These elasticities explain why the overall level of the budget share to food remains surprisingly stable across income levels: the composition of the food basket changes considerably with rising income toward more expensive foods and variety in the diet.

Among the nonfood items that grow disproportionately with rising income are especially house building and repair (elasticity of 4.31), celebrations and related gifts (6.95), and health (2.28), as well as expenditures on items such as bicycles, watches, and radios (4.21).

Table 28—Expenditure shares of foods and nonfoods, by expenditure quartiles, 1986

| Foods/Nonfoods[a] | Share of Total Expenditures[b]<br>Bottom Quartile | <br>Second Quartile | <br>Third Quartile | <br>Top Quartile | <br>Average |
|---|---|---|---|---|---|
| | | | (percent) | | |
| Foods | | | | | |
| Pulses (1) | 27.4 | 25.4 | 25.3 | 23.6 | 24.9 |
| Cereals, roots, tubers (2-6) | 34.2 | 34.5 | 35.0 | 31.2 | 33.2 |
| Other foods, beverages (7-13) | 18.2 | 21.1 | 19.8 | 22.9 | 21.1 |
| Total food | 79.8 | 81.0 | 80.1 | 77.7 | 79.2 |
| Own-produced (percent of total food) | (62.6) | (61.8) | (64.9) | (55.9) | (60.3) |
| Nonfoods | | | | | |
| Clothing (14) | 8.1 | 7.1 | 8.3 | 7.2 | 7.5 |
| Housing (15) | 1.4 | 1.6 | 1.6 | 4.4 | 2.8 |
| Household goods (16-18) | 5.6 | 5.7 | 5.0 | 4.1 | 4.8 |
| Celebrations, luxuries (19,22) | 0.6 | 0.6 | 1.2 | 2.7 | 1.7 |
| Other nonfoods (20,21,23) | 4.5 | 4.0 | 3.8 | 3.9 | 4.0 |
| Total nonfood | 20.2 | 19.0 | 19.9 | 22.3 | 20.8 |
| Total expenditures[b] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Own-produced food (percent of total expenditures) | (50.0) | (50.0) | (52.0) | (43.5) | (47.8) |

Source: International Food Policy Research Institute survey, 1985/86.

Note: Annualization of expenditure shares is based on consumption surveys, January-September 1986.

[a] The figures in parentheses refer to the commodity classifications and expenditure items in Table 29.

[b] This includes the value of own-produced food consumed in the household.

Expenditures on food and nonfood changed considerably during the seasons of the study period in 1986. Average monthly expenditures were highest in the first months of the year but dropped to 76 percent of that level in the April-June period and to 71 percent in July-September. The drop in total consumption was higher among the poor—that is, the bottom quartile—than it was among the top quartile of the households (Table 30). Much of this change in total consumption over the seasons is due to reduced consumption from own-produced food. The further the observations are past the main harvest period early in the year, the lower the consumption from own-produced food. Again, a more pronounced drop in consumption from own-produced food over the seasons is found among the households in the bottom quartile of the expenditure distribution. Later in the year, these households spent increased amounts of resources on purchased food, which is not the case in absolute terms among the top-quartile households. In fact, an opposite direction shows up in spending on food purchases over the season among the poor versus the "rich" households (Table 30, columns 2 and 5, rows 4-6). Also, it is noteworthy that in all seasons the top-quartile households spent about four to five times as much cash for food purchases in the market as households from the bottom quartile. Lower levels of availability of own-produced foods for consumption are combined with lower income levels.

## Table 29—Annual expenditures on foods and nonfoods, by quartiles of total expenditure per capita, 1986

| Foods/Nonfoods | Annual Expenditure per Capita Bottom Quartile | Second Quartile | Third Quartile | Top Quartile | Average | Approximate Income Elasticity[a] |
|---|---|---|---|---|---|---|
| | | | (FRw) | | | |
| Foods | | | | | | |
| 1. Peas and beans | 1,730 | 2,208 | 2,954 | 4,487 | 2,845 | 0.79 |
| 2. Potatoes | 689 | 1,018 | 1,834 | 2,489 | 1,507 | 1.29 |
| 3. Sweet potatoes | 760 | 945 | 868 | 877 | 863 | 0.08 |
| 4. Maize | 529 | 656 | 797 | 1,042 | 756 | 0.48 |
| 5. Sorghum | 89 | 265 | 373 | 939 | 417 | 4.73 |
| 6. Wheat, rice, bread, manioc, cooking bananas, colocase, soya | 86 | 116 | 233 | 601 | 259 | 2.96 |
| 7. Sorghum and banana beer | 603 | 952 | 1,121 | 1,842 | 1,130 | 1.02 |
| 8. Bottled beer and soft drinks | 30 | 21 | 98 | 264 | 103 | 3.86 |
| 9. Animal products | 105 | 277 | 353 | 1,018 | 438 | 4.29 |
| 10. Vegetables and fruits | 260 | 377 | 475 | 723 | 459 | 0.88 |
| 11. Sugar | 29 | 69 | 59 | 215 | 93 | 3.17 |
| 12. Oil | 41 | 32 | 62 | 87 | 56 | 0.56 |
| 13. Other | 82 | 107 | 146 | 203 | 133 | 0.73 |
| Total food | 5,033 | 7,043 | 9,373 | 14,787 | 9,059 | 0.96 |
| Own production | 3,151 | 4,350 | 6,079 | 8,272 | 5,463 | 0.80 |
| Nonfoods | | | | | | |
| 14. Clothing | 504 | 607 | 966 | 1,375 | 863 | 0.86 |
| 15. House building and repair | 87 | 142 | 191 | 845 | 316 | 4.31 |
| 16. Toilet utensils | 144 | 223 | 227 | 277 | 218 | 0.46 |
| 17. Household supplies | 107 | 136 | 200 | 272 | 179 | 0.76 |
| 18. Energy (firewood, coal, batteries, kerosene) | 103 | 138 | 160 | 222 | 156 | 0.57 |
| 19. Celebrations and gifts | 27 | 35 | 120 | 406 | 147 | 6.95 |
| 20. School (tuition, uniforms, paper) | 93 | 77 | 113 | 142 | 106 | 0.26 |
| 21. Health | 60 | 75 | 123 | 336 | 148 | 2.28 |
| 22. Bicycles, watches, radios | 12 | 20 | 20 | 114 | 42 | 4.21 |
| 23. Other | 133 | 196 | 205 | 261 | 199 | 0.48 |
| Total nonfood | 1,270 | 1,649 | 2,325 | 4,250 | 2,374 | 1.16 |
| Total expenditures | 6,303 | 8,692 | 11,698 | 19,037 | 11,433 | ... |

Source: International Food Policy Research Institute survey, 1985/86.

Note: Annualization of expenditures is based on consumption surveys, January-September 1986.

[a] These elasticities ($\Sigma_i$) are not estimated econometrically, but a rough approximation is computed as follows:

$$\Sigma_i = [(EX4_i - EX1_i)/EX1_i]/[(EXT4 - EXT1)/EXT1],$$

where

$\Sigma_i$ = approximate income elasticity,

$EX4_i$ ($EX1_i$) = per capita expenditure on expenditure item i in fourth quartile (first quartile), and

EXT4 (EXT1) = per capita total expenditure, including value of own-produced food (income proxy).

### Table 30—Monthly expenditures on foods and nonfoods per capita in different seasons, 1986

| Expenditure Type/Season | Bottom Quartile | | | Top Quartile | | | Average of All Cases | | |
|---|---|---|---|---|---|---|---|---|---|
| | FRw | Relative Change (Jan-Mar=100) | Percent of Total in Each Season | FRw | Relative Change (Jan-Mar=100) | Percent of Total in Each Season | FRw | Relative Change (Jan-Mar=100) | Percent of Total in Each Season |
| Own-produced food | | | | | | | | | |
| January-March | 325 | 100 | 57.9 | 1,044 | 100 | 52.0 | 619 | 100 | 53.5 |
| April-June | 218 | 67 | 51.8 | 627 | 60 | 40.3 | 398 | 64 | 45.6 |
| July-September | 140 | 43 | 39.4 | 599 | 57 | 38.7 | 349 | 56 | 42.3 |
| Purchased food | | | | | | | | | |
| January-March | 124 | 100 | 22.1 | 650 | 100 | 32.3 | 330 | 100 | 28.5 |
| April-June | 129 | 104 | 30.6 | 561 | 86 | 36.1 | 294 | 89 | 33.6 |
| July-September | 133 | 107 | 37.5 | 507 | 78 | 32.7 | 271 | 82 | 32.8 |
| Total food expenses | | | | | | | | | |
| January-March | 449 | 100 | 80.0 | 1,694 | 100 | 84.3 | 949 | 100 | 82.0 |
| April-June | 347 | 77 | 82.4 | 1,188 | 70 | 76.4 | 692 | 73 | 79.2 |
| July-September | 273 | 61 | 76.9 | 1,106 | 65 | 71.4 | 620 | 65 | 75.2 |
| Nonfood expenses | | | | | | | | | |
| January-March | 112 | 100 | 20.0 | 315 | 100 | 15.7 | 208 | 100 | 18.0 |
| April-June | 74 | 66 | 17.6 | 367 | 117 | 23.6 | 182 | 88 | 20.8 |
| July-September | 82 | 73 | 23.1 | 442 | 140 | 28.6 | 205 | 99 | 24.8 |
| Total expenditures | | | | | | | | | |
| January-March | 561 | 100 | 100.0 | 2,009 | 100 | 100.0 | 1,157 | 100 | 100.0 |
| April-June | 421 | 75 | 100.0 | 1,555 | 77 | 100.0 | 874 | 76 | 100.0 |
| July-September | 355 | 63 | 100.0 | 1,548 | 77 | 100.0 | 825 | 71 | 100.0 |

Source: International Food Policy Research Institute survey, 1985/86.

## Determinants of Subsistence Orientation in Consumption

The production-related analyses in the previous section showed that numerous factors determined the level of subsistence orientation in the farm households. Consumption issues certainly rank high among the households' decision variables concerning subsistence orientation in production. In the following, an attempt is made to identify the major factors that determine this subsistence orientation in consumption by means of a multivariate analysis. This analysis refers to subsistence concept 3 (CX), defined in equation (4) in Chapter 4. It also refers to the theoretical foundation discussed in Chapter 4.

In specifying the model, it was hypothesized that subsistence orientation is determined by availability of production resources and thus by factors that influence the income-earning capacity from agricultural sources. The critical variable that depicts this in the model is the person-land ratio (PLR in Table 31).

Second, it was hypothesized that a higher capital asset base (CAPITAL) reduces pressure on households to avoid production risks and permits more specialization in profitable crops, thus more market integration of the household economy, and thus reduced subsistence orientation.

Third, it was hypothesized that access to off-farm wage employment reduces subsistence orientation because of expanded exchange entitlements.

**Table 31—Regression analysis of determinants of the degree of subsistence orientation in consumption**

| Explanatory Variable[a] | Parameter | t-Value | Mean | Standard Deviation |
|---|---|---|---|---|
| PLR | -0.5737 | -4.40 | 11.16 | 8.25 |
| CAPITAL | -0.0101 | -2.13 | 219.50 | 220.08 |
| WAGES | -7.8941 | -2.85 | 0.48 | 0.37 |
| RISKPER | -13.9794 | -5.47 | 2.35 | 0.40 |
| CHSHARE | 15.7188 | 2.99 | 0.29 | 0.20 |
| Constant | 24.2187 | 3.62 | ... | ... |
| $\hat{R}^2$ | 0.50 | | | |
| F-value | 13.11 | | | |
| Degrees of freedom | 177 | | | |

Note: The dependent variable is the value of own-produced food consumed by the household in percent of total food and nonfood consumption value (including own-produced); CX x 100, as defined in concept 3 in Chapter 4.

[a] Definitions of variables:

PLR = person-land ratio, in persons per hectare (persons per hectare, rather than adult-equivalent persons as in the production analysis, are used here to also account for demand effects).
CAPITAL = household capital stock per capita.
WAGES = wage income over total cash income in current year.
RISKPER = index of household head's perception about crop risks (derived from a specific crop-choice survey; index is the mean of stated level of importance of crop-specific risk on a scale of 1 to 3).
CHSHARE = share of children under five years of age in persons in household.

Fourth, it was noted that individual attitudes and perceptions may influence household choices regarding more or less subsistence orientation. Critical in this respect is a household's perception (that of the wife or husband or both) of crop risks. From a specific survey component (see Table 19) inquiring into household crop-risk perception, a respective variable is derived (RISKPER).

Finally, it was hypothesized that a household's demographic composition, especially a higher share of children in the household (CHSHARE) would have an increasing effect on subsistence orientation. The expectation is that a stronger focus on household production-based food security would be found in households with more small children, where women have less mobility to get involved in off-farm work, which in the study area usually entails long-distance walking and absence from home for long hours.

The results of the regression model (Table 31) suggest a very strong effect of changes in the person-land ratio for subsistence orientation. They also indicate a statistically significant effect of capital assets for reduced subsistence orientation.

The model further suggests that access to wage employment reduces subsistence orientation. Support is also lent to the hypothesis that households with more concern for crop risk have a higher subsistence orientation—consistent with the sample theoretical model in Figure 4. Moreover, life cycle impinges on household economic orientation: households with small children focus more on subsistence orientation.

Most interesting is the level of the effect of reduced availability of land per person on the subsistence orientation in consumption. At sample means, one additional person per hectare reduces the subsistence share by 0.57 percent. Or, in other words, a 10 percent increase in the person-land ratio leads to a reduction in the subsistence share of total expenditures by 1.3 percent. Although statistically highly significant, the level of this reduction, at first glance, is surprisingly low. Two factors are at work here that leave the CX rather stable:

$$CX = X_s / X_{tot}. \tag{9}$$

First, an increase in the person-land ratio (PLR) implies some reduction in agricultural income-earning capacity. Thus, total consumption value ($X_{tot}$) as an income proxy—the denominator in the dependent variable—is expected to drop with rising PLR, leaving the share of subsistence in total consumption high. Thus,

$$PLR \uparrow \rightarrow X_{tot} \downarrow .$$

Second, reduced farm size leads to an increased subsistence orientation ($X_s$) in the use of the remaining land resources for various reasons discussed earlier, that is, the desire to maintain food insurance (see Chapter 5 and Table 7). Thus,

$$PLR \uparrow \rightarrow X_s \uparrow .$$

In combination, both of these forces work in the direction of a rather stable and high share of subsistence food in total consumption when land gets scarcer. Nevertheless, at current population growth rates, the person-land ratio will increase from 11.2 to 16.9 persons per hectare within one decade. This would, other things holding constant, reduce subsistence orientation by 3.3 percentage points from its current level of 47.8 to 44.5 percent.

## Subsistence and Incremental Spending on Food

Two key questions in the context of this study are to what extent incremental expenditures of the households are spent on food and to what extent reduced subsistence orientation impinges on the allocation of means to food consumption. These questions are further evaluated on the basis of a simple Engel curve estimation and thereafter with a model for food-energy consumption. The effects of changes in the CX variable, explained above (Table 31), are thus traced to food expenditures and calorie consumption.

The model explains total expenditures for food (including the value of consumed own-produced food) as a function of total income (for which the aggregate total expenditure values serve as a proxy variable), household size and composition of the household, and the degree of subsistence orientation in the household (see Table 32). This specification of the Engel curve estimation tests the hypothesis that an increased subsistence orientation of the household increases the overall allocation of resources to food consumption, holding income constant. It was further hypothesized that in female-headed households, more is spent on food consumption, holding other things constant. This is a test for the expectation that in households where budget allocations are largely controlled by women, more is spent on basic welfare-related items, such as food, health,

**Table 32—Model of determinants of food expenditures**

| Explanatory Variable[a] | Total Sample<br>Parameter (and t-Value) | Mean | Standard Deviation |
|---|---|---|---|
| ln TOEXCA | 8,605.518<br>(19.52) | 9.24 | 0.43 |
| SUBFOOD | 37.703<br>(3.40) | 49.04 | 15.58 |
| ln CAPITA | -129.491<br>-0.30) | 1.62 | 0.46 |
| FEMHEAD | 1,295.174<br>(2.28) | 0.11 | 0.32 |
| CHSHARE | 1,125.520<br>(1.23) | 0.29 | [illegible] |
| Constant | -73,810.317<br>(-16.30) | ... | |
| Dependent (FOODEX) | ... | 7,826.38 | [illegible] |
| $\hat{R}^2$ | 0.722 | | |
| F-value | 98.4 | | |
| Degrees of freedom | 182 | | |

Note: The dependent variable is FOODEX = expenditure on all food per capita per year (in FRw), including value of consumed own-produced food.

[a] Definitions of variables:

TOEXCA = logarithm of total expenditure per capita.
CAPITA = household size (persons).
FEMHEAD = female-headed households=1, else=0.
SUBFOOD = consumed own-produced food in percent of total expenditures.
CHSHARE = share of children under five years of age in persons in household.

and expenses related to child nurturing. It was finally hypothesized that in larger households, less is spent on food per capita because of potential economies of scale.

The parameter estimates (Table 32) suggest that a 10 percent increase in income (total expenditure) leads to a 10.5 percent increase in food expenditure at sample mean values. As discussed at the outset of this chapter, the tabulations show that a major change in the food basket composition occurs as households become richer and spend more on expensive food items. This is again reflected in the high expenditure elasticity of food found in this model.

More surprisingly, the model results suggest a strong impact of subsistence orientation on food expenditures: a drop of the subsistence share (CX) by one percentage point reduces the total food consumption value, all else remaining the same, by 0.47 percent.

Support is also lent to the hypothesis that female-headed households in general spend more on food consumption at a given income level and level of subsistence orientation than do male-headed households. On average, female-headed households are found to spend 16 percent more on food than do other households at the same income level (size and demographic pattern). To what extent these differences in spending behavior translate into food-energy consumption will be evaluated in the following chapter.

From these analyses, it is concluded that much of incremental income in these communities is spent on food, but that with rising income the food basket substantially changes toward more expensive food items, thus keeping the share of total food expenditures in total expenditures remarkably constant and at a very high level. Within the same income group, reduced subsistence orientation is found to reduce overall spending on food. This phenomenon, also found elsewhere (von Braun, Hotchkiss, and Immink 1989), may be attributed to changes in intrahousehold income control and responsibility, and possibly to fluctuating, more lumpy cash-income sources. The role of transaction cost differentials of household food versus food from the market requires further exploration.

## Composition of Food-Energy Sources

In the following analysis, the focus is on the effects of changes in income and income composition on food-energy consumption at the household level. While it was observed in the expenditure analysis above that households spend the major share of incremental income on food, it is not immediately clear to what extent these incremental expenditures actually lead to incremental food consumption in terms of food energy. In fact, lower income elasticities of calorie consumption are expected, because substantial shifts were observed within the food basket toward more expensive calories when income increases.

The focus on food energy (calories) is because of a hypothesized strong relationship between energy deficiency and nutritional status in this study region and particularly in the poorest households. This is not to say that other food deficiencies, such as proteins, micronutrients, and vitamins—especially vitamin A (Vis, Yourassowsky, and van der Borght 1975)—are not of considerable importance in the highly variable Rwandan local context.

The demand of households for food is not necessarily driven by a perceived demand for food energy. Even at low-income levels, households demand not only low-cost food in terms of cost per calorie but also variety in the diet and a food composition that is seen to be appropriate given certain acquired perceptions and food habits at the specific location.

Although Rwanda is frequently mentioned as a country where rural communities have a very homogeneous diet, this understanding of Rwanda's rural food consumption situation is probably a result of assessments of the consumption situation that are too aggregated.

A disaggregated evaluation of food consumption patterns and food-energy sources as presented in Table 33 shows substantial shifts in the composition of the major sources of energy in the diet when income increases. The figures presented in the table are expressed in terms of calories per day per adult-equivalent person, not on a per person level.[12] They show that in the mid-year survey round in April-June 1986, average calorie consumption stood at 2,643 calories per adult-equivalent in the sample. For comparative purposes, consumption of food energy on a per person per day basis was 2,025 calories (see Table 34). This compares with the average per person dietary-energy supplies of 2,274 calories per day for the country as a whole in the FAO (1985) Fifth World Food Survey.

Looking at individual commodities, most noteworthy in Table 33 is the inferiority of sweet potatoes as indicated by a reduction in the share of sweet potatoes in total calories consumed from 40 percent in the bottom expenditure quartile to 15 percent in the top quartile. This change not only reflects a relative reduction but also an absolute reduction of sweet potato consumption as income increases; or the other way around, increased impoverishment in the area would very substantially lead to increased consumption (and production) of sweet potatoes. This finding is much in line with the findings of Laure (1982, 188) in a neighboring lower-altitude region.

Opposite to sweet potatoes is the consumption behavior toward potatoes, which have a share of 8 percent in the bottom quartile, but 18 percent of calorie consumption in the top quartile. Compared with these substantial changes, the relative positions of pulses and of cereals in calorie consumption change very little (Table 33). Overall calorie consumption, however, is 66 percent higher in the top expenditure quartile in per capita terms than it is in the bottom quartile.

In the whole sample, sweet potatoes provide on average the largest share of all food calories consumed, with 26 percent, followed by peas and beans together covering 25 percent of food energy, and these are closely followed by maize (the major cereal) which covers 23 percent of total calories. The next most important energy sources are potatoes, sorghum beer, and sorghum.

## Effects of Subsistence Orientation, Income, and Land Scarcity on Food Consumption

In a different arrangement of calorie consumption figures by degree of subsistence orientation of households, applying concept 3 of subsistence (CX) as presented in Table

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[12] For computation of adult-equivalents, a World Health Organization (1985) report was consulted. (For children from 1 month to 18 years old, age-related Tables 22, 24, and 25 gave energy-requirement figures. Table 14 was used to estimate the basal metabolic rate [BMR] for different age and height groups of men and women; the BMR was multiplied by the factor for moderate activity from Table 16.) The adult-equivalents in the households refer to the requirement of an average 30-year-old male in the sample of the present study, 2,798 calories a day.

## Table 33—Sources of calories per adult-equivalent per day, by expenditure quartiles, April-June 1986

| Food Item | Bottom Quartile | | Second Quartile | | Third Quartile | | Top Quartile | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake |
| Peas and beans | 451 | 23.0 | 606 | 23.5 | 644 | 23.1 | 915 | 28.2 | 653 | 24.7 |
| Potatoes | 164 | 8.4 | 237 | 9.2 | 495 | 17.8 | 598 | 18.3 | 372 | 14.1 |
| Sweet potatoes | 791 | 40.0 | 767 | 29.9 | 713 | 25.5 | 490 | 15.0 | 691 | 26.2 |
| Maize | 366 | 18.6 | 690 | 26.8 | 644 | 23.1 | 767 | 23.5 | 616 | 23.3 |
| Sorghum | 16 | 1.0 | 46 | 1.8 | 43 | 1.5 | 129 | 4.0 | 58 | 2.2 |
| Wheat, rice, bread, manioc, cooking bananas, colocase, soya | 37 | 1.9 | 10 | 0.4 | 21 | 0.8 | 86 | 2.6 | 38 | 1.4 |
| Sorghum beer | 67 | 3.4 | 117 | 4.5 | 122 | 4.4 | 150 | 4.6 | 114 | 4.3 |
| Bottled beer and soft drinks | 2 | 0.1 | 0 | 0.0 | 9 | 0.3 | 4 | 0.1 | 4 | 0.2 |
| Animal products | 7 | 0.4 | 8 | 0.3 | 30 | 1.1 | 25 | 0.8 | 17 | 0.6 |
| Vegetables and fruits | 52 | 2.6 | 79 | 3.1 | 50 | 1.8 | 69 | 2.1 | 62 | 2.3 |
| Sugar | 2 | 0.1 | 8 | 0.3 | 5 | 0.2 | 8 | 0.2 | 6 | 0.2 |
| Oil | 9 | 0.5 | 6 | 0.2 | 10 | 0.4 | 21 | 0.6 | 12 | 0.5 |
| Total | 1,964 | 100.0 | 2,574 | 100.0 | 2,786 | 100.0 | 3,262 | 100.0 | 2,643 | 100.0 |

Source: International Food Policy Research Institute survey, 1985/86.

Table 34—Calorie consumption per person, by expenditure and farm-size quartiles, survey round 2, May-June 1986

| Quartile | By Expenditure Quartile |  | By Farm-Size Quartile |  |
|---|---|---|---|---|
|  | Average Annual Total Expenditure/Capita[a] | Calories/Person/Day | Average Farm Size | Calories/Person/Day |
|  | (FRw) |  | (hectares) |  |
| Bottom | 6,303 | 1,360 | 0.23 | 1,845 |
| Second | 8,692 | 1,790 | 0.45 | 1,735 |
| Third | 11,698 | 2,089 | 0.75 | 2,039 |
| Top | 19,037 | 2,631 | 1.53 | 2,202 |
| Average | 11,433 | 2,025 | 0.74 | 2,025 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] The expenditure classes are formed on the basis of annual per capita expenditure data from all survey rounds (including consumption of own-produced food).

35, it appears that per capita calorie consumption increases with increased subsistence orientation: the top quartile in terms of subsistence orientation consumes 20 percent more per adult-equivalent person than the bottom quartile. These changes in levels of consumption are not combined with major shifts in the composition of the diet. An exception may be for maize, where in the bottom quartile a substantially smaller share of calories is provided by this crop than in all other quartiles.

Overall, per capita calorie consumption shows a positive correlation with farm size, which is not surprising given the relationship between farm size and income level (Table 34). More surprising is that calorie consumption does not really increase very much with rising farm size: in farms that have an average of 0.23 hectares (the bottom quartile), calorie consumption is only 16 percent lower than in the top quartile, which averages 1.53 hectares. This means—in a rough calculation that takes into account the differences in household size per farm—that a reduction in average farmland per capita by 10 percent is associated with a reduction in calorie consumption by only 2.1 percent. Intensification of agricultural production on a more limited land base and increased off-farm income largely permit the maintenance of food-energy consumption.

While the relationship between farm size and food consumption at the household level appears rather weak, the relationship between income and food-energy consumption is very strong. A first indication of this is given by the comparative tabulation in Table 34, which shows calorie-consumption levels per capita by expenditure quartiles (as a proxy variable for per capita income) in comparison with farm-size quartiles. In the breakdown by expenditure quartiles, calorie consumption per capita is 93 percent higher in the top expenditure quartile than it is in the poorest group, while the bottom quartile has an average expenditure per capita that is 67 percent below the top quartile's average. A comparison of these associations of income and farm size in food-energy consumption—in a simple approach from the relative differences in farm size, income, and calories between the top and bottom quartiles (Table 34)—suggests that a doubling of farm size is associated with a 3.4 percent increase in calorie consumption, but a doubling of income

## Table 35—Calories per adult-equivalent per day, by subsistence quartiles, April-June 1986

| Food Item | Bottom Quartile (Least Subsistence-Oriented) | | Second Quartile | | Third Quartile | | Top Quartile (Most Subsistence-Oriented) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake | Calories/ Day/Adult-Equivalent | Percent of Total Calorie Intake |
| Peas and beans | 656 | 26.8 | 542 | 21.7 | 547 | 20.1 | 871 | 29.6 | 653 | 24.7 |
| Potatoes | 323 | 13.3 | 304 | 12.2 | 456 | 16.8 | 407 | 13.9 | 372 | 14.1 |
| Sweet potatoes | 622 | 25.5 | 695 | 27.8 | 678 | 25.0 | 773 | 26.4 | 691 | 26.2 |
| Maize | 448 | 18.4 | 620 | 24.9 | 744 | 27.4 | 653 | 22.3 | 616 | 23.3 |
| Sorghum | 106 | 4.4 | 24 | 1.0 | 73 | 2.7 | 28 | 1.0 | 58 | 2.2 |
| Wheat, rice, bread, manioc, cooking bananas, colacase, soya | 68 | 2.8 | 41 | 1.6 | 17 | 0.6 | 27 | 0.9 | 38 | 1.4 |
| Sorghum beer | 98 | 4.0 | 167 | 6.7 | 90 | 3.3 | 99 | 3.4 | 114 | 4.3 |
| Bottled beer and soft drinks | 4 | 0.2 | 8 | 0.3 | 1 | 0.0 | 1 | 0.0 | 4 | 0.2 |
| Animal products | 16 | 0.7 | 9 | 0.4 | 29 | 1.1 | 15 | 0.5 | 17 | 0.6 |
| Vegetables and fruits | 64 | 2.6 | 71 | 2.8 | 60 | 2.2 | 55 | 1.9 | 62 | 2.3 |
| Sugar | 11 | 0.5 | 4 | 0.2 | 6 | 0.2 | 2 | 0.1 | 6 | 0.2 |
| Oil | 20 | 0.8 | 9 | 0.4 | 16 | 0.6 | 1 | 0.0 | 12 | 0.5 |
| Total | 2,436 | 100.0 | 2,494 | 100.0 | 2,717 | 100.0 | 2,932 | 100.0 | 2,643 | 100.0 |

Source: International Food Policy Research Institute survey, 1985/86.

Note: Subsistence is defined as the value of own-produced food in percent of total expenditures (concept 3, see Chapter 4).

is associated with a 46 percent increase in calorie consumption.[13] Income and food-energy consumption relationships and the impact of changes in subsistence orientation are further analyzed below in a more refined model analysis.

## Specific Home Goods Production: Water and Wood

The picture of income-expenditure-consumption links would remain incomplete without looking into specific home goods production, especially water and fuelwood acquisition. Water and wood fetching are time-consuming activities. The amount as well as the quality of water and wood gathered can influence sanitation, food preparation, and heating. Water and wood fetching compete with other activities for time.

Water fetching takes about half an hour a day and is performed almost exclusively by women and children. Time for collecting wood adds up to about nine hours per week per household. In two-thirds of all households, only women and children collect wood. Time allocation variables for fetching water and wood are highly correlated with each other.

Table 36 shows the discussed variables broken down by the three cutoff points of calorie consumption. The group with the highest calorie deficiency spends significantly more time on water and wood fetching than the other groups. The share of households that have to buy wood doubles from 8 percent for the best-off group to 16 percent for the worst-off group. These calorie-deficient households tend to live in the most marginal locations, which are disadvantageous for water and wood collection. It may hold that the poorest tend to be short not only in money but also in time, and time constraints are passed on to the children in this group; the percentage of poor households in which only children fetch water or wood increases substantially over that of better-off households, while women's involvement in this activity decreases. Women of calorie-deficient households obviously do not have time to get water or wood. The above analyses show that farmers in the surveyed area react to a rising person-land ratio by changing calorie production toward cheaper calories and higher output per unit of land and by intensifying labor input. It is therefore concluded that the rapid increase of children's work in household services (water, wood) in these calorie-deficient households may suggest that the subsistence food producers (which means the women) have reached a point where they devote all their efforts to subsistence production without being able to generate enough food.

## Chronic and Transitory Food-Energy Deficiencies

The main interest of this study is households at the bottom end of the income scale—the prevalence and nature of their food deficiencies and how these deficiencies are affected by market integration and commercialization of traditional agriculture. Thus it

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[13] It should be noted that this simple calculation neglects the fact that the relationships are not linear between bottom and top quartiles. As shown in Table 34, the second farm-size quartile is even at a somewhat lower calorie-consumption level than the bottom quartile. Land per capita is not linearly related to farm-size differences, as the smallest farms have smaller families. Still, doubling of land per capita in the above calculation is associated with an increase in calorie consumption by only 5.7 percent.

## Table 36—Time spent on household water and wood fetching, by calorie consumption group, 1985/86

| | Calorie Consumption Group | | | |
|---|---|---|---|---|
| Item | More Than 80 Percent of Requirements | 60-80 Percent of Requirements | Less Than 60 Percent of Requirements | Total Average |
| Water | | | | |
| Time fetching water (minutes/day/household) | 34* | 34 | 48* | 36 |
| Time share of family members (percent of household time) | | | | |
| Woman only | 46** | 34 | 16** | 38 |
| Child(ren) only | 27** | 36* | 53*,** | 33 |
| Woman and child(ren) | 23 | 27 | 30 | 25 |
| Family, including husband and others | 4 | 3 | 1 | 4 |
| Wood | | | | |
| Time fetching wood (hours/week/household) | 9 | 7** | 11** | 9 |
| Time share of family members (percent of household time) | | | | |
| Woman only | 40** | 27 | 22** | 34 |
| Child(ren) only | 11 | 14 | 21 | 13 |
| Woman and child(ren) | 22 | 19 | 22 | 21 |
| Family, including husband and others | 27 | 40 | 35 | 32 |
| Share of sample households that purchase wood (percent) | 8 | 4 | 16 | 8 |
| Share of sample households with own wood fields (percent) | 32** | 56** | 44 | 39 |

Source: International Food Policy Research Institute survey, 1985/86.
*Denotes pairs of groups significantly different at the 0.10 level.
**Denotes pairs of groups significantly different at the 0.05 level.

is relevant to look into fluctuations in energy deficiency during the year. In the mid-year survey in May/June 1986, 41 percent of all households were found to consume less than 80 percent of calorie requirements. In the third survey round in August/September, this share had increased to 62 percent.

The detailed and carefully done study in a neighboring lower-altitude zone by Laure (1982, 154), based on a smaller sample that is traced over a full year, shows similar large seasonal variations in calorie consumption. In that sample the percentage of households below 80 percent of recommended calorie requirements varies between 35 percent of households during January and June (1980) and 70 percent of households during August and December.

Surveys like this, which consist of a series of recall surveys that cover consumption over a short period (in this case, it is a week in each survey round), suffer from the problem of erratic fluctuations because of special incidents affecting household consumption levels at any given point in time. Examples of interfering events are, for instance, festivities, visits, and absence of certain household members. Over time these fluctuations should be expected to level off; therefore, households that for special reasons unrelated to income were found in, for instance, the calorie-deficient group of sample households at one point, would probably not be found in that group again during a later survey round. This should, of course, not be expected on average over time for these poor whose consumption also fluctuates but is in general below requirements due to lack of income and other entitlement failures that make them chronically food insecure.

A rather high persistence of low-end poverty is found to be represented by a fair amount of stability of household consumption deficiencies in the sample. Of the 41 percent of households below 80 percent of requirements in the May/June survey, 70 percent had been in that group in the first survey round in February/March. Sixty-five percent of the households in the calorie-deficient group in August/ September had been found in the same group in May/June. This persistence in low-end poverty, as represented by continuous calorie deficiencies, has implications for policy interventions for nutritional improvement. Targeting of measures for nutritional improvement and for income and employment generation may have a much more effective result if directly geared toward these low-end poverty groups. Frequently, and not only in Sub-Saharan Africa, fluctuations in poverty are a phenomenon that complicate policy intervention. To some extent, this is the case in the study area, but a fair amount of persistent and stable low-end food poverty is still found and requires the attention of program designers and policymakers.

## Determinants of Calorie Consumption

The above discussion on relationships derived from simple tabulations on the structure of calorie consumption and its differences between various farm-size and income classes reveals a complex problem of a number of exogenous factors that determine actual food-calorie consumption levels.

In the following an attempt is made to explain calorie consumption levels at the household level, and in this context, to evaluate the role of more or less subsistence orientation in food-energy consumption. The model is designed in the following way: dependent variables are calories consumed per day per adult-equivalent person as observed during the three survey rounds in the weekly recall surveys on quantities of food use from stocks and own production as well as food purchases.

The specification of the model and related explanatory variables are based on the following hypotheses. Rising income, as represented by the total expenditures per capita (as an income proxy), leads to increased calorie consumption, but decreasingly so at the margin, which is depicted by a logarithmic transformation of the total expenditure variable (TOEXCA, Table 37).

Increased food prices are expected to lead to reduced calorie consumption, and changes in price ratios in favor of a food item are expected to lead to absolute or at least relative switches toward the lower-calorie food items. These price relationships are depicted by two key crops from the staple food bundle that are much traded—potatoes and sweet potatoes (POTPRICE, POTSWEET). A fair number of regional differences and seasonal price changes in these commodities were captured by the survey at the household level.

It is further hypothesized that an increased share of subsistence food from own production raises overall calorie consumption beyond the income effect of production (SUBCAL). This may be so because of differentials in transaction costs and differentials

## Table 37—Determinants of calorie consumption

| Explanatory Variable[a] | Parameter | t-Value | Variable | Elasticity at Mean |
|---|---|---|---|---|
| TOEXCA | 1,243.084 | 20.91 | 6.70 | 0.476 |
| POTPRICE | -24.518 | -2.44 | 8.55 | -0.080 |
| POTSWEET | -135.269 | -1.32 | 0.84 | ... |
| SUBCAL | 5.221 | 3.71 | 75.91 | 0.152 |
| CAPITA | -84.951 | -6.12 | 5.51 | -0.179 |
| CHSHARE | 1,323.005 | 8.66 | 0.29 | 0.147 |
| FEMSHARE | 5.122 | 3.60 | 15.37 | 0.030 |
| ROUND 1 | 496.410 | 6.29 | 0.33 | 0.063 |
| ROUND 2 | 437.296 | 5.40 | 0.33 | 0.055 |
| Constant | -6,093.713 | -13.42 | ... | ... |
| (CALADEQ) | ... | ... | 2,609.40 | ... |
| $\hat{R}^2$ | 0.598 | | | |
| F-value | 93.1 | | | |
| Degrees of freedom | 549 | | | |

Note: The dependent variable is CALADEQ = calories per day per adult-equivalent person.

[a] Definitions of variables:

TOEXCA = income proxy; logarithm of total expenditure per capita per month in respective survey round (in FRw).
POTPRICE = price of potatoes in FRw per kilogram.
POTSWEET = price ratio of potatoes over sweet potato price.
SUBCAL = consumed own-produced calories in percent of total calories.
CAPITA = household size (number of persons).
CHSHARE = share of children under five years of age in persons in household.
FEMSHARE = female income share over total income.
ROUND 1 = dummy variable for survey round 1.
ROUND 2 = dummy variable for survey round 2.

in propensities to consume own-produced versus purchased food. Given the time costs of households in food acquisition from market versus off-take of own-produced food, the transaction-costs argument is probably of greater relevance in this environment where food acquisition requires a substantial time investment in going to market.

Income level, form of income (cash versus kind), and income control within the household may matter for actual levels of food consumption. Regarding income control, it is hypothesized that incremental cash income in the hands of women (FEMSHARE) has an incremental positive effect for food-energy consumption, holding household income constant.

It is also hypothesized that household characteristics have a bearing on the levels of calorie consumption. In larger households, scale economies may be achieved, and therefore per capita calorie consumption may fall, with rising household size (CAPITA); a test is made for changes in average calorie-consumption levels as a function of the share of children in the household population (CHSHARE). The variable CHSHARE depicts two things: first, in general, household calorie consumption per adult-equivalent increases when the share of children under age five increases—this could be partly related to increased energy expenditure of breast-feeding women. Second, the variable depicts and corrects potential estimation problems of the child-specific adult-equivalent rates because these depend partly on the assumed activity levels of children, about which very little is actually known (a "moderate" activity level was assumed). A more than moderate activity level of children would lead to an increased (positive) parameter estimate. This variable thus functions also for corrective purposes to reduce distortions in the analysis.

Finally, differences are sought between the three survey rounds in terms of calorie consumption beyond the above-mentioned factors. Such differences may stem from seasonal variations in energy expenditure due to variation in workload or climatic conditions or both. It was hypothesized that in August, when the lightest workload is observed in agriculture (survey round 3), energy consumption is down because of reduced expenditure of energy.

The model results suggest a strong relationship between income and calorie consumption, thus reaffirming the suggestions derived from the earlier tabulations. A 10 percent increase in income raises calorie consumption at the sample mean by 4.8 percent. Substantial differences exist between the top and bottom income groups' use of incremental income for food energy. An additional FRw 100 (US$1.11) of per capita monthly income would raise household-specific calorie consumption by 6.5 percent in the bottom-quartile households and by 5.5 percent in the top-quartile households.

The calorie-consumption information of this section combined with the expenditure information discussed in the previous section suggests that household spending per calorie increases rapidly with rising income. Calorie consumption per capita increases less than food expenditures across the expenditure quartiles. While the households in the bottom quartile spend an average FRw 7.02 (US$0.08) per 1,000 calories, the households in the top quartile spend 77 percent more (FRw 12.42, or US$0.14).

Clearly, households respond with overall reduced calorie consumption when food prices increase, as indicated by the parameter estimate for the staple food price (potato price, which correlates closely with cereal price). A 10 percent increase in the potato price would reduce calorie consumption by 0.8 percent. On the other hand, no significant relationship is found between changes in the potato and sweet potato price ratio for calorie consumption.

Reduced subsistence orientation is found to reduce calorie-consumption levels. A combination of forces of transaction costs and women's control over subsistence probably are at play here. The effect is statistically significant: a reduction in the share of subsistence calories in total calories by 10 percentage points from, say, the currently high mean of 75 percent to 65 percent would reduce calorie consumption by 2 percent, holding all other variables constant. Thus, reduced calorie availability from own production as a consequence of further-increased land-scarcity effects will have an adverse effect on calories beyond the income-level and income-control effects, though the magnitude of the effect does not seem to be large.

In larger households, less is consumed for every additional person in the household. As indicated by the parameter estimates for the CAPITA variable, an additional person would reduce average calorie consumption levels per capita in the household by 85 calories or 3.3 percent, holding everything else constant. An increased share of children in the household has the opposite effect.

## A Special Case: Farmers Displaced by Factories' Tea Plantations

The commercialization effects of agriculture on production, employment, and income take many different forms. The loser-gainer situations in the commercialization process are very complex. One such case is the displacement of farm households by the tea factories in the area. As described in Chapter 3, the establishment of two tea factories in the study area led to the displacement of a considerable number of farm households that had already settled where the factories' tea gardens were later established. The displacements occurred partly in the late 1970s and partly in 1984/85, shortly before the survey for this study was undertaken. A specific subsample of displaced farm households was surveyed to evaluate the short- and medium-term effects of the severe disruption these households had experienced. This small subsample cannot claim to be representative of the effects of expropriation in the tea area in general, but it gives some typical insights.

### Compensation

The expropriation of 32 interviewed households occurred between 1977 and 1985. One-half of them were notified in the same year the expropriation took place, so they could hardly plan for the change; one-third were informed a year before the expropriation, and the rest still earlier. All households lost land and 24 (75 percent) also lost their houses. Only those who lost their houses received cash compensation of an average FRw 130,736 (a range of FRw 1,600-500,000), which seems somewhat related to the value of the houses. Most of the 24 households that got compensation received it in the same year as the expropriation (71 percent). Twenty out of the 24 households that lost their houses used part of the compensation to build a new house. Only 19 out of the 32 who lost land purchased new fields. The field purchases of 8 of them are documented and show rather high prices compared with other land purchases recorded in the survey. They reported 148 percent higher prices per hectare than the average price reported for land purchases in the same period by other farm households in the sample who had purchased land. Local immobility and desire for fast acquisition of land after the expropriation may have contributed to the high purchase prices.

Seventy-two percent of all 32 expropriated households reported that they now have a smaller farm than before. Seven of the 8 farms that did not get any cash compensation were able to grow potatoes in the Gishwati forest area. The access or nonaccess to this land in the forest had an important impact on the agricultural production, income, and entitlement to food of the displaced households.

### Agricultural Production of Displaced Farmers

The displaced farmers who did not get access to land in Gishwati have, on average, much smaller farms than the rest of the sample (Table 38). In general, fields of the displaced farmers are more frequently on steep slopes or hilltops. They did not have, on average, more access to rented land (17 percent).

The displaced households produce mainly potatoes, though they also have substantial production of maize and pulses, on average similar to other farmers. The comparatively low sweet potato production is due to the specific location of the displaced farmers. They also reported having grown few sweet potatoes before displacement.

### Off-Farm Employment

The small farm size of the displaced households (without Gishwati fields) leads to the question of whether they can supplement their modest agricultural income through off-farm work. As Table 39 shows, in April-June 1986 the displaced farmers earned an average of 31 percent more off-farm income than the households that were not displaced. But the displaced farmers without Gishwati fields had absolutely less. All displaced

Table 38—Farm characteristics and production of displaced and other farmers, 1985/86

| Item | Not Displaced | Displaced: All Displaced | Displaced: Without Gishwati Fields | Displaced: With Gishwati Fields |
|---|---|---|---|---|
| Farm size (hectares) | 0.62 | 0.68 | 0.47 | 0.86 |
| Fields on upper hill or top of hill (percent) | 30.0 | 51.0 | 24.0 | 60.0 |
| Inherited fields (percent) | 44.0 | 20.0 | 11.0 | 23.0 |
| Purchased fields (percent) | 17.0 | 34.0 | 67.0 | 24.0 |
| Cash rental fields (percent) | 18.0 | 17.0 | 17.0 | 18.0 |
| Fields in Gishwati forest (percent) | 10.0 | 19.0 | ... | 24.0 |
| Harvest (kilograms)[a] | | | | |
| Potatoes | 738 | 1,226 | 382 | 2,525 |
| Peas and beans | 83 | 90 | 35 | 133 |
| Maize | 97 | 198 | 80 | 294 |
| Sorghum | 155 | 47 | ... | 85 |
| Sweet potatoes | 227 | 26 | ... | 47 |
| Number of households | 181 | 32 | 21 | 11 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] Refers to main crop season only (1985/86).

farmers had a higher proportion of tea-factory work, but none of them had access to employment by public projects.

## Income and Consumption

Displaced households earned most of their cash income from off-farm work, potatoes (in Gishwati), and sorghum beer sales. They sold about twice as much sorghum beer as other households, and it appears that this was a main income-earning activity resorted to by women in these households, once their fields were lost.

It is difficult to establish an appropriate income account for the displaced households because of their special situation. Their overall work effort may also be different from the rest of the main sample and could not be assessed appropriately in the survey. Their welfare situation, however, may be reasonably depicted by their food and nonfood consumption and expenditure (Table 40).

The main difference in expenditure patterns between expropriated and other households is the much higher housing expenditure of displaced farmers. Evidently, this reflects the immediate consequence of displacement, including the loss of houses. But also excluding housing, the nonfood expenditures of the displaced households are higher than those of other households. This has not negatively affected food expenditures and calorie consumption in the sample of displaced households. On average, they consume even more than the rest of the sample households in the September/October 1986 survey. Yet it should be noted that only a small sample forms the basis of this comparison. Based on this small sample, there is no indication that food consumption suffered due to the disruption in the displaced households. Despite the reduced farm-resource base, entitlements to food were maintained via the off-farm employment opportunities, the rather special opportunity of potato-growing in the forest area, and the compensation for expropriated houses.

## Table 39—Off-farm work of displaced and other farm households, 1985/86

| | Frequency of Work[a] | | | |
|---|---|---|---|---|
| | | Displaced | | |
| Type of Work/Earnings | Not Displaced | All Displaced | Without Gishwati Fields | With Gishwati Fields |
| | | (percent) | | |
| Agricultural daily worker | 13.0 | 13.0 | 25.0 | ... |
| Public projects | 16.0 | ... | ... | ... |
| Tea factory | 21.0 | 57.0 | 58.0 | 55.0 |
| Craftsmen | 13.0 | 17.0 | 17.0 | 18.0 |
| Others | 37.0 | 13.0 | ... | 27.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |
| Average off-farm earnings, April-June 1986 (FRw) | 1,543 | 2,028 | 1,456 | 2,357 |
| | (100.0) | (131.4)[b] | (94.4)[b] | (152.8)[b] |

Source: International Food Policy Research Institute survey, 1985/86.

[a] The numbers represent only frequency, not length, of employment.

[b] Relative to the "not displaced" group = 100.0.

## Table 40—Expenditures and food consumption of displaced and other farm households, 1986

| Item | Not Displaced | Displaced without Gishwati Fields | Displaced with Gishwati Fields |
|---|---|---|---|
| Total nonfood expenditure (FRw) | 167 | 433 | 315 |
| House building/repair (FRw) | 23 | 275 | 120 |
| Nonfood expenditure without house expenditure (FRw) | 144 | 158 | 194 |
| Total food expenditure (including value of own-produced) (FRw) | 565 | 670 | 762 |
| Own-produced food (FRw) | 305 | 361 | 461 |
| Total monthly expenditure without house expenditure (FRw) | 709 | 828 | 957 |
| Food expenditure in percent of total expenditures without house expenditure | 80 | 81 | 80 |
| Own-produced food value in percent of total expenditures without house expenditure | 43 | 44 | 48 |
| Own-produced food expenditure in percent of total food expenditure | 54 | 54 | 60 |
| Calories per day per adult-equivalent person | 2,058 | 2,718 | 2,481 |
| Number of households | 181 | 21 | 11 |

Source: International Food Policy Research Institute survey, 1986.

Note: Data in this table are for September/October 1986, when the special survey of displaced households was included (round 3 of survey).

This result should not be misinterpreted to mean that all displaced households had a smooth transition without hardship. Direct observation and discussion with households affected by the change revealed many problems in coping with the situation. Also, it should be stressed that only those households that resettled in the area could be traced and surveyed. Others who left the area may be in a different situation.

## Summarized Findings

Very high shares of incremental income in the study households are spent on food. Food expenditures thereby increase almost in parallel with total income. Subsistence orientation is much driven by land availability in the study area. Therefore, a rapid increase in land scarcity puts the desired subsistence orientation of households in a squeeze. Subsistence orientation, however, is a choice in view of risky food and labor market environments, and this orientation toward subsistence food provision is reduced when households have higher capital-asset levels and access to wage employment. An expanded rural wage labor market and a buildup of the asset base of households, or in more general terms, better integrated rural financial markets, would reduce subsistence orientation.

At the household level, preference structures contribute to subsistence orientation in a significant way. Reduced subsistence orientation was found to have a shifting effect on the Engel curve and a decreasing effect on food-energy consumption beyond income and price effects. Transaction costs and income-control issues related to subsistence food appear to be at play. Female-headed households are found to have a higher propensity to spend income on food, holding income constant, and a higher cash-income share earned by women in the households was found to have an incremental effect on food-energy consumption at the household level. Therefore, channeling resources to women may have additional benefits for welfare effects related to food consumption in this setting.

The special case of farmers displaced by tea factories in the study area is found to have a major adverse effect on the households' asset situation. However, due to off-farm employment opportunities and access to crop-cultivation opportunities in forest lands, displaced households identified in the study setting were able to maintain food-energy consumption levels above minimum requirements. The expropriated farmers were pushed into the natural forest and onto the hilltops, which raises production-sustainability concerns.

# 7

# CONSUMPTION-NUTRITION-HEALTH LINKS

A major objective of this research is to trace changes in agricultural production—especially its increased commercialization—via their employment and income effects to effects on consumption and nutrition. The nutritional effects are not only driven by the income-consumption linkages but also, as conceptualized in Figure 2, are affected by the health and sanitation environment of the household.

## Structure and Prevalence of Malnutrition among Children

The nutritional status of children between six months and six years of age is evaluated by means of anthropometric measurements, that is, weight and height measurements related to each other and to the age of the child and compared with the standard reference population. As reference population statistics, the World Health Organization-U.S. National Center for Health Statistics (WHO-NCHS) standards were used to identify the prevalence of malnutrition and the nutritional status of individual children. From these variables, indications for more long-term nutritional status problems and short-term malnutrition are derived:

- Height-for-age represents a long-term indicator, as it reflects the past growth of the child, which is the result of numerous factors beginning with birth weight and including morbidity and consumption-deficiency episodes throughout childhood.
- Weight-for-age represents a long-term and, to some extent, a short-term indicator, as it is related to the child's height and the extent of present undernourishment given a certain height.
- Weight-for-height indicates a short-term nutritional situation.

In referring to these conventionally used measures, it is pointed out by Payne (1987) that child growth is not an indicator that enables one to distinguish food deprivation from infection as an initiating event. In acknowledging the limitations (and strengths) of such nutrition indicators for policy and for evaluation, the authors refer to Payne's comprehensive article and the quoted literature therein.

The child population in the survey households was weighed and measured before the initial survey and in each survey round. It was found that in the beginning of 1986, 21.5 percent of children were growth retarded—that is, below 90 percent of the reference height-for-age. About 10 percent of the children were found to be underweight—that is, below 80 percent of the threshold level of weight-for-age. Five percent of them showed symptoms of wasting—that is, their weight-for-height was below 90 percent of reference standards (see Table 41).

The short-term indicator of nutritional staus—weight-for-height—shows substantial change over the survey period: in the presurvey measurements, a much higher percentage of children was found in the category of wasting (11 percent), but this percentage share dropped to about 2 percent precisely one year later in survey round 3. The percentage of children below standard weight-for-height in late 1985 (round 0) is

## Table 41—Prevalence of malnutrition among children aged 6-72 months in the sample population, 1985/86

|  |  | Percent of Children[a] |  |  |  |
|---|---|---|---|---|---|
| Indicator | Number of Children | Round 0 | Round 1 | Round 2 | Round 3 |
| Below 90 percent height-for-age | 181[b] | 18.8 | 21.5 | 23.2 | 23.2 |
|  | 238 | ... | 20.2 | 22.3 | 21.8 |
| Below 80 percent weight-for-age | 181[b] | 11.0 | 9.9 | 13.2 | 8.8 |
|  | 238 | ... | 10.1 | 12.6 | 10.1 |
| Below 90 percent weight-for-height | 181[b] | 11.0 | 5.0 | 3.9 | 2.2 |
|  | 238 | ... | 5.5 | 3.4 | 2.1 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] The data for 181 children are taken from a subsample. The same 181 children were surveyed in all rounds. The 238 children include those 181, and the 238 are the same children in all rounds.

[b] These measurements were taken in December 1985.

assumed to be related to the severe drought-induced food shortage in that year and to a dramatic food-price inflation that was partly a result of the local shortage and partly a result of the generally short food supply in the East African region, which also had an impact on food prices in the study area.

## Food-Energy Deficiencies and Malnutrition

Levels of nutritional status in comparison with a reference population can be conveniently expressed in terms of Z-score values. A Z-score value of zero indicates a child who is "normal"; a negative Z-score value indicates an anthropometric measurement below the one in the reference population; and a threshold level of below -2 Z-scores is commonly considered an indication of a serious nutritional problem.[14]

In Table 42, Z-score values are presented for the three anthropometric measurements, and these values are broken down by households that consumed less than 80 percent of calorie requirements versus the rest of the households in the three survey rounds. There is a clear indication that children in the households that consume less than 80 percent of the requirements show a worse nutritional status than children in households that consume above the 80 percent cutoff point. The differences are pronounced in the height-for-age and weight-for-age indicators, but not in the weight-for-height indicators. The latter may be a surprise but is explainable: the anthropometric measurements were taken roughly at the same time as the food-consumption levels in the households were surveyed. Effects for short-term weight losses may not be appropriately captured by current food-consumption levels because there are time lags involved. The clear association between nutritional status and calorie deficiency for height-for-age and weight-for-

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[14] Z-scores = Actual Measurement - 50th Percentile Standard/Standard Deviation of 50th Percentile Standard.

### Table 42—Prevalence of malnutrition among children aged 6-72 months, by household calorie-consumption levels, 1985/86

| Round/ Consumption Group | Number of Children | Height-for-Age | | Weight-for-Age | | Weight-for-Height | |
|---|---|---|---|---|---|---|---|
| | | Average Z-Score | Below 90 Percent of Standard Median | Average Z-Score | Below 80 Percent of Standard Median | Average Z-Score | Below 90 Percent of Standard Median |
| | | | (percent) | | (percent) | | (percent) |
| Round 1 | | | | | | | |
| Total | 238 | -1.33 | 20.2 | -0.62 | 10.1 | 0.29 | 5.5 |
| Less than 80 percent of requirements | 48 | -1.72 | 27.1 | -0.97 | 18.8 | 0.11 | 6.3 |
| Not less than 80 percent of requirements | 190 | -1.23 | 18.4 | -0.53 | 7.9 | 0.34 | 5.3 |
| Round 2 | | | | | | | |
| Total | 238 | -1.51 | 22.3 | -0.60 | 12.6 | 0.29 | 3.4 |
| Less than 80 percent of requirements | 8 | -1.77 | 26.1 | -0.78 | 15.9 | 0.21 | 3.4 |
| Not less than 80 percent of requirements | 150 | -1.37 | 20.0 | -0.49 | 10.7 | 0.33 | 3.3 |
| Round 3 | | | | | | | |
| Total | 238 | -1.48 | 21.8 | -0.62 | 10.0 | 0.24 | 2.1 |
| Less than 80 percent of requirements | 160 | -1.51 | 23.1 | -0.63 | 10.0 | 0.24 | 1.9 |
| Not less than 80 percent of requirements | 78 | -1.41 | 19.2 | -0.58 | 10.3 | 0.22 | 2.6 |

Source: International Food Policy Research Institute survey, 1985/86.

age may indicate that households with a more persistent calorie-consumption problem are also the ones in which the retarded and underweight children are found to a larger extent.

This is also reflected in the higher prevalence of malnutrition found among households that have deficiencies below 80 percent of requirements. For instance, in survey round 1, 19 percent of children from households consuming below 80 percent of requirements were found to be seriously underweight, but only 8 percent in the other households (below 80 percent of the standard median weight-for-age). The significance of these apparent differences by calorie-consumption levels has to be evaluated further in the context of the household's health and sanitation environment and demographic structures. This will be done in a multivariate analysis below.

## Malnutrition and Commercialization

Before entering into the multivariate analysis, a further exploration of basic patterns of malnutrition and prevalence of malnutrition will be looked at briefly. First, children from households with larger farms show a lower prevalence of growth retardation and underweight (Table 43). Second, there is apparently a strong positive association between increased per capita income approximated by total expenditure per capita, and long-term nutritional status as represented by height-for-age indicators and related

## Table 43—Prevalence of malnutrition among children aged 6-72 months, by various socioeconomic and farm-household characteristics, March 1986

| Group | Number of Children | Height-for-Age |  | Weight-for-Age |  | Weight-for-Height |  |
|---|---|---|---|---|---|---|---|
|  |  | Average Z-Score | Below 90 Percent of Standard Median | Average Z-Score | Below 80 Percent of Standard Median | Average Z-Score | Below 90 Percent of Standard Median |
|  |  |  | (percent) |  | (percent) |  | (percent) |
| Total sample | 219 | -1.49 | 21.5 | -0.60 | 12.3 | 0.29 | 3.7 |
| Farm-size quartiles (average hectares) |  |  |  |  |  |  |  |
| Bottom (0.23) | 54 | -1.74 | 29.6 | -0.78 | 14.8 | 0.28 | 5.6 |
| Second (0.45) | 56 | -1.64 | 25.0 | -0.70 | 14.3 | 0.28 | 5.4 |
| Third (0.74) | 51 | -1.33 | 13.7 | -0.56 | 9.8 | 0.34 | 2.0 |
| Top (1.53) | 58 | -1.23 | 17.2 | -0.39 | 10.3 | 0.28 | 1.7 |
| Expenditure quartiles (total per capita) |  |  |  |  |  |  |  |
| Bottom | 54 | -1.75 | 27.8 | -0.65 | 11.1 | 0.37 | 1.9 |
| Second | 57 | -1.59 | 21.1 | -0.74 | 17.5 | 0.23 | 7.0 |
| Third | 54 | -1.39 | 20.4 | -0.56 | 5.6 | 0.28 | 1.9 |
| Top | 54 | -1.22 | 16.7 | -0.46 | 14.8 | 0.30 | 3.7 |
| Subsistence orientation in agricultural production (concept 1)[a] |  |  |  |  |  |  |  |
| Bottom quartile | 60 | -1.39 | 23.3 | -0.58 | 13.3 | 0.27 | 0.0 |
| Second quartile | 49 | -1.66 | 26.5 | -0.72 | 16.3 | 0.25 | 4.1 |
| Third quartile | 56 | -1.36 | 16.1 | -0.60 | 12.5 | 0.22 | 10.7 |
| Top quartile | 54 | -1.53 | 20.4 | -0.53 | 7.4 | 0.44 | 0.0 |
| Subsistence orientation in consumption (concept 3)[b] |  |  |  |  |  |  |  |
| Bottom quartile | 46 | -1.70 | 28.3 | -0.70 | 15.2 | 0.35 | 2.2 |
| Second quartile | 59 | -1.69 | 22.0 | -0.68 | 15.3 | 0.37 | 5.1 |
| Third quartile | 57 | -1.45 | 24.6 | -0.72 | 12.3 | 0.18 | 5.3 |
| Top quartile | 57 | -1.14 | 12.3 | -0.34 | 7.0 | 0.28 | 1.8 |
| Households growing tea | 37 | -1.38 | 18.9 | -0.64 | 13.5 | 0.25 | 2.7 |
| Households not growing tea | 182 | -1.51 | 22.0 | -0.60 | 12.1 | 0.30 | 3.8 |
| Households with commercial potato field in Gishwati | 91 | -1.22 | 16.5 | -0.46 | 9.9 | 0.31 | 2.2 |
| Households without commercial potato field in Gishwati | 128 | -1.68 | 25.0 | -0.71 | 14.1 | 0.28 | 4.7 |

Source: International Food Policy Research Institute survey, 1985/86.

[a] Value of agricultural produce consumed in the household in percent of production value (concept 1, see Chapter 4).

[b] Own-produced food consumed in percent of total expenditure (concept 3).

prevalence rates of malnutrition. About 28 percent of children in the bottom quartile are found below 90 percent of standard height-for-age, but only 17 percent in the top quartile of per capita expenditure. Much less clear is the association between income and weight-for-age and weight-for-height.

In one section of Table 43, households are grouped by the degree of agricultural subsistence orientation. The bottom quartile represents those households with very little subsistence orientation of their production, while the top quartile represents households that are largely subsistence-oriented (concept 1 of subsistence, as defined in Chapter 4). In none of the three nutrition indicators is a relationship apparent between agricultural subsistence orientation and nutritional status, expressed in either Z-scores or prevalence rates. Of course, numerous other factors require joint attention with the degree of agricultural commercialization, and, therefore, tabulations give only limited insight. Disaggregating the linkages between agricultural production, income, and nutritional outcome is, for that reason, essential to understanding the process.

A broader approach toward the relationship between subsistence orientation in consumption and the nutritional effects is taken with the tabulation in another section of Table 43. Households are arranged by quartiles of degree of subsistence orientation in consumption (concept 3). Comparing the bottom quartile with the top quartile indicates a much-reduced degree of stunting, on average, and a lower prevalence of children below 90 percent of height-for-age (12.3 percent versus 28.3 percent). Not as pronounced but also in the same direction is the impression from the weight-for-age figures, but not the short-term nutritional indicators of weight-for-height, which for the March 1986 survey round (used for Table 43) are at very low levels of prevalence. It should be noted, however, that income is not held constant in this tabulation. As shown earlier, the more subsistence-oriented households tend to have a larger farm-resource base and higher income. Nevertheless, the finding of an apparent positive association between nutritional improvement and higher degrees of subsistence orientation in consumption is in line with the earlier finding from the calorie consumption models, which indicated that an increased degree of subsistence orientation in consumption was associated with an increased level of calorie consumption in that case beyond household income levels. Further evaluation of these effects in multivariate analysis follows below. Especially household-specific demographic factors may be influencing some of these tabulated results, as will be shown below.

Straightforward comparisons of nutritional status in households that are involved in major commercialization activities—that is, growing tea versus not growing tea and cultivating commercial potato fields (in Gishwati) versus not cultivating such fields—are presented at the bottom of Table 43. While no apparent differences show up in the comparisons between tea growers and other farm households, a lower extent of malnutrition prevails in households with commercial potato fields. It should be stressed, however, that having such fields in the Gishwati forest was associated with higher income, both from the fields and even excluding these fields—that is, higher-income households were those that got more access to these new income sources. So this comparison may largely reflect a positive relationship between income and nutritional improvement. The following multivariate analysis sheds further light on this.

## Causes of Malnutrition: Multivariate Analysis

The preceding descriptive account of the prevalence of malnutrition has shown that short- and long-term determinants of malnutrition consist of a complex set of interacting variables. It is certainly not only current household-level food availability, for instance, measured in calorie consumption per capita, that determines children's stunting or wasting as assessed in the anthropometric measurements. Interactions between low levels of food consumption and a poor health situation of children reinforce each other and lead to deterioration of nutritional status.

These complexities will be addressed in more detail with the help of a multivariate analysis. This analysis ties in with the conceptual framework outlined in Chapter 4. Changes in levels of food consumption were traced from employment, income, and agricultural production effects. The food-consumption effect, therefore, enters this model analysis. Also, as shown in Figure 2, the health and sanitation environment impinges on the nutritional status of children and is therefore treated as exogenous in this analysis. The objective is to explain differences and short-term changes in children's nutritional status. Height-for-age, weight-for-age, and weight-for-height indicators defined in terms of Z-score values are the dependent variables of the following models presented in Table 44.

It should be noted at the outset that such anthropometric models, which make use of cross-sectional information and short-term-change information over the rather short-term survey period, can only achieve a relatively low level of explanatory power in terms of coefficient of determination ($R^2$). Quite commonly, $R^2$ of 0.05 to 0.10 are considered normal or at the higher end for such models. This is so because of numerous factors that cannot be fully captured in such models without a long-term, child-specific data base. Especially important among these factors are the determinants of the long-term growth history of children, which for the elder children is a function of the household food and health environment many years before; children's birth weight, which may be partly a function of the mother's health at the time; specific disease circumstances; and child-specific genetic potentials for growth, which can be only partly approximated by the assessment of the mother's and father's heights (which are actually incorporated into the models below). To the extent that these factors are randomly distributed across the sample, which can be fairly assumed for the most important source of noise in such data—that is, the genetic differences between children—this does not impinge on the robustness of parameter estimates (Balderston et al. 1981).

The three models are specified along a set of hypotheses, and actual field data collection was designed accordingly to generate the variables for this set of models. It was hypothesized that increased calorie consumption at the household level leads also to increased calorie consumption for individual children who capture a certain share of incremental household calories. It was assumed that the nutritional-improvement effect of increased calorie consumption is diminishing at the margin, which means that at higher levels of calorie consumption an incremental calorie has less and less nutritional benefit for the children in the household. These hypotheses are depicted by the CALORIES and the CALORIES SQUARED variables in the model (Table 44).

It was also hypothesized that current levels of sickness (SICK) at the time of the anthropometric measurement have an adverse effect on the medium- and short-term measures of nutritional status, that is, the weight-for-age and weight-for-height indicators. Furthermore, it was specifically hypothesized that children who are infested with intestinal worms (WORMS) are less efficient in making use of incremental food-energy consumption, and therefore are, at given levels of household food consumption, less well-off nutritionally (see Stephenson 1980). A better sanitation environment, as represented by CLEAN TOILET as an indicator variable for sanitation quality, would be expected to improve children's nutritional status.

Household demographic structure, size, and composition and individual child demographics can play an important role in children's nutritional performance. It may be

## Table 44—Multivariate analysis of determinants of nutritional status of children aged 6-72 months, 1985/86

| Explanatory Variable[a] | Model 1 | | | | Model 2 | | | | Model 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height-for-Age (HAZ) | | | | Weight-for-Age (WAZ) | | | | Weight-for-Height (WHZ) | | | |
| | Estimated Parameter | t-Value | Mean of Variable | Standard Deviation of Mean | Estimated Parameter | t-Value | Mean of Variable | Standard Deviation of Mean | Estimated Parameter | t-Value | Mean of Variable | Standard Deviation of Mean |
| CALORIES | 1.69E-04 | 3.50 | 2,561 | 1,035 | 9.36E-05 | 2.52 | 2,561 | 1,035 | 3.08E-04 | 2.58 | 2,578 | 1,044 |
| CALORIES SQUARED | b | ... | ... | ... | b | ... | ... | ... | -4.88E-08 | -2.41 | 7,732.319 | 6,112,009 |
| SICK | -4.80E-04 | -0.07 | 3.51 | 6.87 | -0.0182 | -3.44 | 3.51 | 6.87 | -0.0208 | -4.64 | 3.50 | 6.82 |
| WORMS | -0.2521 | -2.68 | 0.50 | 0.50 | -0.0671 | -0.93 | 0.50 | 0.50 | 0.0791 | 1.30 | 0.51 | 0.50 |
| CLEAN TOILET | 0.5295 | 5.55 | 0.60 | 0.49 | 0.2151 | 2.94 | 0.60 | 0.49 | b | ... | ... | |
| ln CAPITA | 1.1396 | 3.81 | 1.82 | 0.31 | 0.9359 | 4.08 | 1.82 | 0.31 | 0.3046 | 1.57 | 1.82 | 0.31 |
| BORDER | -0.1356 | -2.65 | 3.34 | 1.78 | -0.1613 | -4.12 | 3.34 | 1.78 | -0.0725 | -2.19 | 3.36 | 1.75 |
| SEX | -0.3004 | -3.18 | 1.53 | 0.50 | 0.2573 | -3.56 | -1.53 | 0.50 | -0.0722 | -1.19 | 1.54 | 0.50 |
| AGE | -5.35E-03 | -1.99 | 44.39 | 20.86 | -3.39E-03 | -1.65 | 44.39 | 20.86 | 1.19E-03 | 0.69 | 43.96 | 20.95 |
| HEIGHT OF MOTHER | 0.0296 | 3.65 | 158.13 | 5.83 | 0.0169 | 2.72 | 158.13 | 5.83 | 5.85E-03 | 1.30 | 158.16 | 5.79 |
| HEIGHT OF FATHER | 0.0358 | 3.41 | 166.65 | 4.58 | 0.0199 | 2.48 | 166.65 | 4.58 | 1.96E-03 | 0.29 | 166.60 | 4.62 |
| Constant | -14.0105 | -6.34 | ... | ... | -8.3254 | -4.72 | ... | ... | -1.8473 | -1.49 | ... | ... |
| Dependent Variables | | | | | | | | | | | | |
| HAZ | ... | ... | -1.50 | 1.23 | ... | ... | ... | ... | ... | ... | .. | ... |
| WAZ | ... | ... | ... | ... | ... | ... | -0.65 | 0.92 | ... | ... | ... | ... |
| WHZ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.26 | 0.77 |
| $\bar{R}^2$ | 0.13575 | | | | 0.09401 | | | | 0.05643 | | | |
| F-value | 10.78547 | | | | 7.46429 | | | | 4.79772 | | | |
| Degrees of freedom | 613 | | | | 613 | | | | 613 | | | |

[a] Definitions of variables:

| | | | |
|---|---|---|---|
| CALORIES | = calories per adult-equivalent per day. | ln CAPITA | = logarithm of household size in number of persons. |
| CALORIES SQUARED | = (calories per adult-equivalent per day)². | BORDER | = birth order of child; 1=first born, 2=second, and so forth. |
| SICK | = number of days sick last month. | SEX | = sex of child; 1=male, 0=female. |
| WORMS | = dummy for medium or heavy load of worms in stool examination; 1=positive results, 0=no or low infestation. | AGE | = age in months at time of anthropometric measurement. |
| | | HEIGHT OF MOTHER | = height of mother in centimeters. |
| CLEAN TOILET | = dummy for clean toilet; 1=clean, else=0. | HEIGHT OF FATHER | = height of father in centimeters. |

[b] Not in equation.

commonly assumed that in larger households with a high children-women ratio, child-care quality and nurturing activities may suffer; that children at the upper end of the birth order are less well taken care of because of the mother's time constraints; and that in most African rural communities, boys perform less well in nutritional-status terms than girls. Beyond that, age-specific differences are controlled for in the nutritional-status indicators, but it is hypothesized that age differences in the Z-score values, which are already normalized for the age-specific standard deviations, will have only a weak effect for differences in nutritional status.

Height of parents is introduced into the model to capture differences within and between ethnic groups. There is a fair amount of range from the rather tall-growing Tutsi population to the short-growing Twa (pygmy) population in the area. These, however, are the extreme, represented to only a minor extent in the sample, which consists almost entirely of Hutu population. Yet within the same ethnic group, the height of parents, insofar as genetically determined, may have an effect on the height of children.

The dependent variables stem from three points of observation in 1986 from each of the three survey rounds. In survey round 1 (February), only one measurement was taken, and this enters the analysis. In survey rounds 2 (May) and 3 (September), two measurements of children were taken at the beginning and at the end of each round. The mean values of these two measurements are included in the model analysis. Testing has been done for differences specific to survey rounds in the anthropometric measurements besides the explanatory variables just discussed, but no statistical differences have been found beyond the variables actually included in the model.

The results of these multivariate analyses are presented in Table 44. Of the most important results, the following will be highlighted in brief.

As hypothesized, a strong nutritional improvement effect of the incremental food consumption is found, and in the case of the short-term nutrition indicator (WHZ) it is also, as hypothesized, decreasing at the margin. The latter result was not found in models 1 and 2 for the height-for-age and weight-for-age models, respectively, so the CALORIES SQUARED variable was dropped from the model.

To the extent that subsistence orientation had an incremental effect on calorie consumption—as identified in Chapter 6—increased commercialization would somewhat diminish the level of the positive calorie-child growth [illegible]. The order of magnitude of this effect, however, is minuscule at the margin and is much overcompensated for by the favorable income effects of commercialization.

The calorie-consumption effect on nutritional improvement is found to be positive and statistically highly significant. The order of magnitude of even the total effect of increased calorie consumption on nutritional improvement, however, is not very high, as becomes clearer in the following computations that make use of the parameter estimates. If household-level calories increased by 10 percent in a household that consumes 2,000 calories per adult-equivalent person, the Z-score value of weight-for-height would increase for children in this household, holding all else constant, by 0.021 (8 percent of the mean value of the sample's weight-for-height). At the same levels of calorie consumption (2,000 per adult-equivalent), a 10 percent increase in calories would improve the Z-score height-for-age value by 0.035 Z-scores (2.3 percent) and the weight-for-age Z-score value by 0.019 (2.9 percent). While these calorie-anthropometry links do not appear large, they are found in this study to be of a much larger magnitude than in two comparable studies in Kenya (Kennedy and Cogill 1987) and in the

Philippines (Bouis and Haddad 1990) and also of somewhat larger magnitude than in a similar study in The Gambia (von Braun, Puetz, and Webb 1989).

Further analysis may be required to explore the effects of diet composition on nutritional-status performance, especially the extent to which increased commercialization of subsistence agriculture changes diet composition. The effects of stable and sustained increases of food-energy consumption on nutritional status, as compared with effects of short-term increases, also need to be explored further. The complex dynamics of the consumption-nutrition linkages could not be fully captured with the short time period covered. Also, the nonlinearity in consumption-nutrition relationships, as identified in the weight-for-height model, may have a more complex structure. It is not unlikely that both of these factors—dynamics of relationships and nonlinearities—may lead to an underestimation of the impact of consumption shortfalls on nutrition. Moreover, energy expenditures are not accounted for. Household-level calories per adult-equivalent person are therefore only a rough approximation of (in-)sufficiency.

The health and sanitation-related variables (SICK, WORMS, CLEAN TOILET) show some interesting and sizable effects. As expected, current underweight (weight-for-height and weight-for-age) is substantially a result of current or recent morbidity or episodes of morbidity. This is not the case for the height-for-age model, which shows a strong effect of worm infestation on the long-term nutritional status of children. The effect is large: for children severely affected by worm infestation (which is the case for half of the child population) this means, holding all else constant, a reduced Z-score value by a quarter of the standard deviation, or in other words, 17 percent of the mean value of the long-term nutritional indicator (HAZ).

Somewhat surprisingly, no significant correlation was found between the three health- and sanitation-related variables. A good sanitation environment, as represented by the CLEAN TOILET variable, has a positive effect beyond the specific morbidity variables (SICK, WORMS). Again, a statistically significant and large impact of improved household sanitation conditions is found for children's nutritional status. A CLEAN TOILET variable should be interpreted as a proxy for more generally improved household-sanitation conditions. The parameter estimate suggests that improved sanitation conditions, in comparison with the poor conditions found in 40 percent of the households, lead to an improvement of about 33 percent in both height-for-age and weight-for-age indicators.

In terms of magnitude, the effects of health and sanitation improvement are certainly much larger than those of overcoming the food-energy deficiency and emphasize the importance of strengthening the rural health system for nutritional improvement. However, it should also be stressed that improving household sanitation and coping with sickness in this environment are not free of charge. Time costs and cash costs for both are considerable, and as shown in the expenditure analysis, the top quartile of households ranked by expenditure per capita spend considerably more than the rest of the population on health care. The approximate income elasticity of health expenditures was 2.28 (Table 29). Increased income, therefore, not only has a nutritional-improvement effect via the food consumption link but also through the health and sanitation link.

Some of the variables related to demography and population growth show interesting results. Contrary to the study hypothesis, an increased household size is found in this sample to be positively related to nutritional improvement and significantly so for the long-term nutritional-status indicator and the medium- to long-term one (HAZ, WAZ).[15] Positive economies of scale in the household economic system may be a reason for this. For example, in a small household of, say, mother and children with husband working off-farm, a sick child brought to the health center would much more affect income earning and child nurturing for the remaining family than in a larger household unit with another caretaker (including an elder child) around.

However, the surprising positive effect of larger household size on anthropmetric status—holding all else constant—must not be misinterpreted as a positive impact of population growth on nutritional-status improvement and thus on poverty alleviation. As argued by Birdsall and Griffin on the impact of rapid population growth on poverty, there is some theory but little hard evidence. "People make decisions about family size in an environment where they are bombarded by a variety of signals, opportunities, and constraints" (Birdsall and Griffin 1988, 50).

The demographic variables related to specific children—that is, birth order, sex, and age of child—all work in the expected direction as hypothesized above. Contrary to the Asian experience, here girls are significantly and substantially better off in terms of nutritional status than are boys. Children of a higher rank in terms of birth order are, all else being equal, significantly worse off. This is so although the study controls for age of child and has an age-normalized dependent variable. There clearly seems to be an increased marginalization of the incremental child. This probably relates to the mother's capacity for child-nurturing activities. Finally, it is confirmed that parents' height has a significant effect on children's height-for-age and weight-for-age. While these parental variables improve the explanatory power of the models, they were found to have no significant effect on the parameter estimates for the remaining variables.

## Summarized Findings

The results of this analysis underscore the fact that malnutrition in this environment is to a very large extent a health problem that needs to be addressed by the health and sanitation services.

Household food-consumption levels are, of course, important but do not dominate the nutrition problem as measured by children's growth performance. Both the food-consumption and health-related determinants of nutrition can be stimulated toward growth and nutritional improvement through income linkages and provision of rural services. Specialization and commercialization of agriculture with improved market integration can be part of this process to the extent that it generates increased real income and employment for the poor. Clearly, a narrow focus on food production alone, with a food self-sufficiency concept for the household in mind, will not be sufficient for nutritional improvement if it does not lead to rapid income growth. The less that rapid growth of real per capita income can be stimulated in this area with increasingly limited production resources, the more important is delivery of effective and efficient health and sanitation services to contribute their potential for nutritional improvement.

While the consumption analysis in Chapter 6 showed that increased subsistence orientation has a beneficial effect for household calorie consumption beyond a given income level, the nutrition-related analysis in this chapter points at a very marginal effect that this calorie-consumption effect of subsistence orientation may have on nutritional status and suggests that this marginal effect is much overcompensated for by the favorable income effects of commercialization. Improvement of health and sanitation is key to rapid improvement of child welfare. Clean toilets, diarrhea control, and cures for intestinal worms—all low-cost measures—have a large impact on child growth performance in this setting.

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[15] This is contrary to what is found in a similar analysis for households in rural Gambia, where, however, households are on average three times as large as in this sample (see von Braun, Puetz, and Webb 1989).

Of special concern are the households pushed into the most marginal areas in the process of population growth and increasing scarcity of land resources. For these long-term developments in the area—which are of direct and indirect importance for sustainability of rural life and, in that context, for the health and nutrition of children—rapid expansion of improved agricultural production practices and new technology is required. This issue is addressed in the next chapter.

# 8

# LONG-RUN PERSPECTIVES FOR RURAL DEVELOPMENT

So far, the impact of commercialization on production and employment has been discussed within a framework of comparative static analysis. Yet, the socioeconomic conditions and relationships that were found in the survey may change over time because of the dynamic impacts of population growth, investment and disinvestment, technical change and social differentiation.

This chapter will concentrate on two aspects of the development process that seem to be of crucial relevance for long-run changes in the socioeconomic situation of rural households, the carrying capacity of the regional economy, and thus, indirectly, the access of the rural population to food. One of these aspects concerns further social differentiation that might result from unequal scope and pace of participation in market integration among rural households. It is at least hypothetically conceivable that this might cause an increasing differentiation in terms of capital accumulation and thus favor an uneven distribution of incomes. Such tendencies are of particular interest as they affect changes in the distribution of farm sizes.

The other aspect relates to the envisaged impact of population growth on the further prospects of commercialization. Subsistence requirements of a growing rural population and economic interests in commercialization of farm produce compete for scarce resources, namely, land. As the population continues to grow, the households' marketable surplus may tend to shrink in favor of subsistence production. The change in factor proportions—the rise in person-land ratios in particular—may also initiate changes in technology and labor use. The outcome of this may be not only an intensification of farm labor input but also a growing "commercialization of labor" via off-farm work. These envisaged adjustments at the household level have considerable implications for the regional economy that will be discussed on the basis of long-run simulations in the last part of this chapter.

## Changes in Farm-Size Structure via the Land Market

It was argued by several authors in the 1970s that one of the long-run effects of increasing commercialization of semisubsistence agriculture might be the favoring of a social differentiation among rural households (see, for example, Griffin 1974 and Jacoby 1971). The basic argument underlying this hypothesis is that in the process of commercialization, those households that enter the market economy earlier than others gain an advanced position in terms of capital accumulation and resulting income flows. Their level of cash income is raised because of an increasing specialization and participation in the exchange economy. These farmers would reinvest their cash profits in order to further increase their resource base. In the absence of productive investment opportunities outside the agricultural sector and in the expectation of increased prices of land and agricultural commodities, it is likely that such investment would concentrate to a certain extent on farmland.

When there are no legal constraints on the land market—for example, the restriction or even complete prohibition against selling and buying farmland, as found in many agrarian societies where communal landownership predominates and no private ownership exists—this might lead to a concentration of farmland. The resulting inequality of distribution of landownership and access to farmland is further aggravated when it is the resource-poor farmers, in particular, who sell farmland or parts of it in order to meet immediate cash requirements in stress situations when the income flow is interrupted—for instance, in a drought or when sudden high expenses are incurred for health care.

Transactions of farmland via the purchase market have indeed played a role in Rwanda, and in the study area in particular. On average, farmers in the sample had acquired 20 percent of their land by purchase.

However, both the number of transactions per year and the volume of farmland transferred in the study area has declined drastically in recent years. According to the land registry office of Giciye *commune*, the number of farmland transactions has varied from 1 to 6 per year since 1977, while the number of transactions registered between 1965 and 1976 varied from approximately 40 to 135 transactions per year. This tendency is confirmed by results of the IFPRI survey (subsample). This decline in transactions accompanied a rapid increase in land prices.

The Rwandan government makes legal interventions in the land-purchase market. These interventions aim to prevent social differentiation by controlling access to the land market through prohibition of farmland purchases by households that already have 2 or more hectares and of land sales by those who have only 0.5 hectare or less (Buschmann 1985). As a consequence, the possibility of getting at least temporary access to farmland via cash rental arrangements has gained importance. In 1985/86 the average share of land rented for cash in total farm size was 16.6 percent in the survey households. As the rent normally has to be paid in advance, those farmers are favored who have higher cash liquidity and who can even afford to pay in advance for several seasons to ensure a medium- to long-term right of use.

Coming back to the original hypothesis concerning an impact of increasing commercialization on social differentiation and land concentration, the subsample survey results do not show that farmers with higher degrees of commercialization in agricultural production are more engaged in farmland acquisition than others (further details can be found in Blanken 1989).

A special case is commercial potato production in Gishwati. The survey results indicate that access to Gishwati land is not evenly distributed among all sample households and that the respective size of Gishwati land varies considerably within the sample. There are indications that given the high land prices on the purchase market, which can almost be considered prohibitive for any further transactions, investment has shifted to potato production in the Gishwati area.

## Commercialization and Population Pressure—A Simulation Model

The following is an attempt to simulate the aforementioned second important feature of the long-run development process—namely, the effect of rising population pressure on allocation of farm resources (that is, land and labor) between subsistence needs, marketing of products, and off-farm labor supply.

## Theoretical Background

Observations of farmers' behavior in economic environments such as this suggest that security of subsistence typically has top priority in production decisions. This implies that available land is allocated to crops that serve for home consumption—if land availability permits—until a desired degree of subsistence is reached. This behavior is driven by risks and uncertainties in the food and off-farm labor market and by an undeveloped capital market. As the farm population grows, more land is required for subsistence, first to the detriment of remaining fallow, but later also at the cost of marketable surpluses. Thus the rapid population growth in the region may impose a limit to commercialization of agricultural production. This limit might appear even sooner if the reduction of fallow periods happens to have a negative impact on soil fertility and yields.

Evidently, this decline of marketable surplus and the fallback into subsistence may be slowed down or even totally avoided by means of agricultural investment and technical innovation. The introduction of land-saving technologies will certainly be of paramount importance in the years to come. Yet chances for high rates of technical progress during the immediate future are rather small. Innovations with low external inputs do not so far appear promising under the conditions of smallholder agriculture in the region. There is some scope for erosion control and agroforestry systems, some of which are quite promising but have so far proven to be difficult to implement. The survey indicates that, as person-land ratios grow, farmers tend to intensify the labor input per hectare, enabling them to increase crop yields and to reduce the decline in per capita subsistence production that accompanies population growth. Significant and sustainable rates of productivity increase, however, will require a rising use of external inputs, particularly new seeds and mineral fertilizer. This need, however, imposes a problem because the purchase of external inputs requires the availability of cash, which is more and more constrained by the decline of marketable surpluses.

Given these limits to an acceleration of growth in agricultural production, it is evident that nonagricultural employment gains more and more importance. Theories of farm households suggest that such activities become more attractive as limited farm resources cause the agricultural marginal-value product to decline relative to nonagricultural income opportunities (see, for example, Nakajima 1970 and Singh, Squire, and Strauss 1986). The results of the survey tend to support these theories: households with larger person-land ratios spend a significantly higher share of their total labor capacity on nonagricultural activities, partly (women) in home production for sorghum beer brewing and partly (men) in off-farm employment. Hence, as a result of ongoing population growth and land scarcity, farm households do not seem to fall back into a noncommercialized state. They rather shift the emphasis from the marketing of agricultural produce to the commercialization of parts of their labor force. They tend to develop toward mixed employment patterns.

In principle, this emerging structure of rural households holding multiple occupations in on-farm and off-farm employment would certainly provide rather good opportunities for a sustainable regional economic development. The nutritional requirements would have to be increasingly met by purchasing food out of incomes earned in nonagricultural employment. Whether or not and to what extent such a change can be realized, and whether this will facilitate the nutritional situation, will depend on the availability of sufficient employment opportunities, on the propensity to spend the resulting income on food, and finally on the real price of food and the wage rate.

The simulation model presented subsequently is an attempt to generate a rough quantitative estimate of the future dimension of this development challenge. It is strictly confined to the sample households; it does not simulate the overall regional development. It is concerned with the prospects for the long-run development of the production systems, the marketable surplus of agricultural products, and the potential supply of labor. It does not address itself to the market for agricultural products or to the regional demand for nonagricultural labor.

The model consists of two components. One is a demographic component that projects future demographic change based on the current age structure of the sample population and observed demographic variables (fertility, mortality). The other is a resource allocation and production component that describes the likely response of land use systems, production, and labor use to the population pressure projected by the demographic component. The consequences of technical change going beyond the impact of intensified labor use due to population growth are analyzed in a second scenario.

### The Demographic Component

Continuing high rates of population growth are seen to be the most important factor to bring about changes in the farming systems prevailing in the study area.

The demographic model assumes that neither immigration nor emigration will occur in the area represented by the sample households during the simulation period and that the land basis observed in 1985 will not change during the next two decades.[16]

Following are the major results of the demographic forecast. If the demographic parameters[17] observed during the period 1978-83 were to continue for the next two decades, the total sample population would more than double. This corresponds to an average annual growth rate of 4.1 percent for the period 1985-95 and 3.9 percent for 1985-2005.[18] The distribution of the total sample population by different age groups does not change much given current parameters (Table 45).

The average person-land ratio increases from 5.51 in 1985 to12.01 in 2005.[19] The resulting rate of growth (4.0 percent a year) is slightly higher than the average annual

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[16] This assumption also means that the absolute amount of land in the Gishwati area will remain constant for those households and their offspring who had access in 1985/86, while those households that did not have any Gishwati land will not have any in future years.

[17] The relevant demographic parameters for the model have been taken from different sources. The birth rates of five-year-old cohorts were taken for Gisenyi *prefecture*. A sex ratio at birth of 100 is assumed for the purpose of the model. The detailed birth rates by age groups are shown in Appendix 2, Table 54. While detailed information on the sex and age cohort-specific mortality rates are available on a national level for infants of different groups below four years of age only, no official mortality rates could be found for children and adults of both sexes. Therefore, the sex and age cohort-specific mortality rates have been computed from the sex and age distribution of the total Rwandan population according to the official censuses of 1978 and 1983. The detailed death rates by sex and age groups are shown in Appendix 2, Table 55.

[18] According to the communal censuses of 1978 and 1983, the average population growth was 4.2 percent a year for Giciye *commune*.

[19] The person-land ratio is defined as the number of adult-equivalent persons per hecta[illegible] (see Appendix 2, Table 56 for coefficients used to calculate the number of adult-equivalent persons).

### Table 45—Shares of different age groups in total sample population, 1985-2005

| Age Group | 1985 | 1995 | 2005 |
|---|---|---|---|
| Below 15 years | 49.2 | 50.5 | 49.4 |
| 15-55 years | 43.8 | 42.2 | 43.1 |
| Above 55 years | 7.0 | 7.3 | 7.5 |

Source: Authors' model projections.

population growth rate of 3.9 percent. The average consumer-worker ratio will remain largely unchanged.[20]

Table 46 contains these household characteristics broken down by person-land-ratio quartiles. This shows that for the highest person-land-ratio quartile, the person-land ratio will more than double from the already high level, while the increase is less dramatic in the lowest person-land-ratio quartile. The table further reveals that, in terms of the consumer-worker ratio, workers of households in the highest quartile have to support fewer household consumers; this will remain the same for quite some time.

In 1985, 23.4 percent of the population fell in the group of the top person-land-ratio quartile (least amount of land), but 20 years later, 74.8 percent of the population will be in that class (Table 47). Of course, these are not predictions, but status quo extrapolations indicating which agrarian structure will exist in the future if current fertility and mortality rates continue and if the nonagricultural economy within or outside the region does not absorb more of the farm population than in the past.

## The Resource Allocation and Production Component

It has already been shown that the allocation of land to the various crops and cropping systems highly depends on both the altitude and the person-land ratio of the households. From this observation, a dynamic simulation model is derived that analyzes the effects of the demographic development on adjustment processes in the farming systems that might take place in the future.

### Table 46—Person-land ratio and consumer-worker ratio, 1985-2005

| | | | | Lowest and Highest Person-Land-Ratio Quartile | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Average | | | 1985 | | 1995 | | 2005 | |
| Ratio | 1985 | 1995 | 2005 | Low | High | Low | High | Low | High |
| Person-land ratio[a] | 5.51 | 7.93 | 12.01 | 1.97 | 10.87 | 2.68 | 15.76 | 3.72 | 23.94 |
| Consumer-worker ratio[b] | 1.28 | 1.33 | 1.28 | 1.36 | 1.18 | 1.40 | 1.28 | 1.33 | 1.24 |

Source: Authors' model projections.

[a] Adult-equivalent persons per hectare.

[b] Consumer-equivalents per adult-equivalent person.

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[20] The consumer-worker ratio has been calculated by dividing the number of consumer-equivalents by the number of adult-equivalent persons. The number of consumer-equivalents per household has been computed by using the coefficients given by Matlon (1982). (See also Appendix 2, Table 57.)

**Table 47—Distribution of sample population by person-land-ratio quartiles, 1985-2005**

| | Percent of Population in Person-Land-Ratio Quartiles (Total Sample) | | | | | |
|---|---|---|---|---|---|---|
| | Share of Households, | Share of Population | | | | |
| Person-Land-Ratio Quartile[a] | 1985 | 1985 | 1990 | 1995 | 2000 | 2005 |
| Less than 2.84 | 25.0 | 21.7 | 16.4 | 8.5 | 5.5 | 3.5 |
| 2.85-4.44 | 25.0 | 27.1 | 16.8 | 15.4 | 10.7 | 7.2 |
| 4.45-6.85 | 25.0 | 27.8 | 30.2 | 22.5 | 18.4 | 14.5 |
| More than 6.85 | 25.0 | 23.4 | 36.6 | 53.6 | 65.4 | 74.8 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Authors' model projections.

[a] Adult-equivalent persons per hectare.

It is assumed, however, that all subsystems to be found at the end of the simulation period already exist in the base year 1985/86. Again, the results indicate a status quo extrapolation, which indicates the scope of future production that seems realistically conceivable if no fundamental changes are introduced exogenously. In a first step, the cropping patterns of different altitude and person-land-ratio groups have been calculated from the subsample households, taking only the most important crops and cropping systems into account.

Table 48 summarizes the cropping patterns of six subsystems that have been identified. Increasing person-land ratios due to population growth cause households to shift from one subsystem to another, that is, to increase the share of labor-intensive crops, such as sweet potatoes, and the index of cropping intensity. The simulation model captures this effect. As farm households move into another person-land-ratio group, they reallocate their agricultural land and adopt the cropping patterns of the new person-land-ratio group.

It is further taken into account that input use is also adjusted accordingly as the person-land ratio changes. The survey results suggest that this applies primarily to the intensification of the labor input per hectare. Therefore, in the next step of the simulation, the total agricultural labor input per hectare has to be determined. Regression analysis revealed that the person-land ratio is the most significant variable in explaining differences in total labor input per hectare. The following semilogarithmic equation was chosen to depict this population-labor input relationship:

$$\begin{aligned} \text{TDHA} &= 98.661 + 352.435\ \text{lnPLR}; \qquad (10) \\ &\qquad (t = 6.44) \end{aligned}$$

F-value = 41.5, $R^2 = 0.549$,

where TDHA is the total labor input per hectare and lnPLR is the logarithm of the person-land ratio.

Output is also expected to change with increased labor inputs per unit of land in the different crops. It is assumed that yields correspond to the respective person-land-ratio

Table 48—Shares of different crops and cropping systems in total farm size, yields, and labor use, by altitude and person-land-ratio group, 1985

| Item | Altitude 1 (Below 2,300 meters) Ratio Group 1 | Altitude 1 (Below 2,300 meters) Ratio Group 2 | Altitude 1 (Below 2,300 meters) Ratio Group 3 | Altitude 2 (Above 2,300 meters) Ratio Group 1 | Altitude 2 (Above 2,300 meters) Ratio Group 2 | Altitude 2 (Above 2,300 meters) Ratio Group 3 |
|---|---|---|---|---|---|---|
| Area shares (percent) | | | | | | |
| Maize, sole stand | 7.5 | 12.7 | 9.2 | 6.7 | 6.1 | 20.4 |
| Maize, mixed | 13.5 | 10.6 | 9.2 | 26.3 | 20.8 | 33.9 |
| Sorghum, mixed | 22.0 | 20.1 | 26.1 | 6.5 | 10.3 | 15.0 |
| Sweet potatoes | 14.7 | 22.9 | 31.3 | 0.9 | 7.4 | 15.9 |
| Beans, sole stand and mixed | 3.8 | 11.6 | 14.5 | 0.4 | 3.8 | 3.3 |
| Peas, sole stand and mixed | 9.0 | 10.2 | 7.5 | 38.9 | 20.8 | 7.4 |
| Index of cropping intensity[a] | 45.6 | 55.0 | 61.9 | 43.8 | 40.8 | 56.4 |
| Yields/hectare (kilograms) | | | | | | |
| Maize, sole stand | 763 | 1,131 | 1,217 | 763 | 1,131 | 1,217 |
| Maize, mixed[b] | 4,883 | 3,860 | 2,609 | 4,883 | 3,860 | 2,609 |
| Sorghum[b] | 3,090 | 3,626 | 4,218 | 3,090 | 3,626 | 4,218 |
| Beans | 891 | 1,090 | 967 | 891 | 1,090 | 967 |
| Peas | 412 | 409 | 628 | 412 | 409 | 628 |
| Sweet potatoes | 4,500 | 5,200 | 6,000 | 4,500 | 5,200 | 6,000 |
| Potatoes | 9,782 | 7,573 | 7,244 | 9,782 | 7,573 | 7,244 |
| Labor use | | | | | | |
| Person-days/hectare/year[c] | 214 | 270 | 445 | 223 | 285 | 305 |
| Family (percent of total) | 63 | 70 | 88 | 67 | 78 | 81 |
| Nonfamily (percent of total) | 37 | 30 | 12 | 33 | 22 | 19 |
| Reciprocal exchange (percent of nonfamily) | 72 | 78 | 93 | 55 | 78 | 81 |

Source: International Food Policy Research Institute survey subsample, 1986.

Note: The person-land-ratio group is derived from total farm size, including Gishwati; ratio group 1 denotes the lower tercile and ratio group 3 the upper tercile of the households in each altitude group.

[a] Cropland use is aggregated on the basis of the respective crop's area share and duration of growing on the land (in fractions of 12 months).

[b] In megajoules per hectare.

[c] Adult-equivalent persons per hectare.

group in the base year. The model simulates yields changing according to present observation as a farm moves to another person-land-ratio group. The respective yields of 1985/86 are shown in Table 48. In general, yields increase with rising person-land ratios for potatoes and maize-beans-potatoes, but the average yields are considerably lower for the higher person-land-ratio groups. One explanation for this might be that commercial potato production, in particular, requires high cash expenditures for seeds and fungicides, and to a lesser extent for wage labor. Thus, farmers with higher income and higher cash liquidity are favored, and input intensity with seeds and fungicides is probably higher for the more land-rich group. The same holds for maize-beans-potatoes, where often—due to liquidity constraints at sowing time—a plant density could be observed that was suboptimal from an agronomic point of view. This may be a case where yield-increasing labor supply effects (Boserup effects) are constrained by farmers' inability to finance external inputs (Boserup 1981).

## Impact of Increasing Population Pressure on Labor Use and Production

In this section the results obtained by the model projections for 1985/86 will be used as the base year when the development of food production is analyzed.

Two different scenarios are distinguished: while scenario 1 is exclusively based on the endogenous changes in agricultural labor input, overall land-use intensity, and changes in the cropping patterns as described so far, technological change effects at constant overall labor-input levels are assumed in scenario 2. As improved varieties were already available in 1985/86, the yields of beans, peas, potatoes, and sweet potatoes (all in sole cropping) are projected to increase by 2.75 percent a year, which implies an increase of 50 percent by the year 2000. This is a rather optimistic assumption. According to Delepierre (1985), on a national level the yields of sweet potatoes and potatoes increased during 1966-83 by an average of 1.6 percent and 0.4 percent a year, respectively, and they are projected to increase further by 1.8 and 0.4 percent a year, respectively, during 1983-2000. On the other hand, the yields of the legumes under consideration dropped by 0.6 percent a year (beans) and by 0.1 percent a year (peas) during the same period. Legume yields are projected to decrease further by 0.8 percent a year (beans) and 0.1 percent a year (peas) until 2000. When projecting the yield development of the four crops, Delepierre assumes a more widespread adoption of improved varieties in the future, but emphasizes that—due to the further reduction of fallow periods and the cultivation of marginal land in the process of continuing population growth—the higher yield potential of the new varieties might not be fully used, and that these new varieties might only partly compensate for the loss in soil fertility.

No improved varieties of maize and sorghum exist for the higher-altitude regions of Rwanda and are very unlikely to be available in the near future. Therefore, the projected increase in the average yields of maize and sorghum is due only to the intensification of agricultural labor input, with no differences between the two scenarios.[21]

Table 49 summarizes the model projections for the production of major crops and total calorie production per consumer-equivalent for 1985-2005. The total calorie production per consumer-equivalent is shown for total farm sizes including Gishwati land (commercial potatoes) on the one hand, and excluding Gishwati land on the other.

In scenario 1, production will increase for maize (+8 percent), sorghum (+24 percent), beans (+12 percent), and sweet potatoes (+40 percent), and decline for peas (-18 percent) and potatoes (-8 percent). In scenario 2, production will increase for all crops, but most rapidly for sweet potatoes and beans.

Looking at the overall calorie supply from own production, Table 49 shows that in scenario 1, calorie production (with farm size including Gishwati) will increase by 11 percent, with a growth rate of 0.5 percent a year. Total calorie production without Gishwati will be increased by 17 percent in the year 2005. This corresponds to an average annual increase of 0.8 percent.

In scenario 2, the average total calorie production will increase 31 percent by the year 2005 when total farm size with Gishwati is taken. This corresponds to an average increase of 1.4 percent a year.Calorie availability from own production per consumer-equivalent and per year will drop by 44 percent in scenario 1 (or by 39 percent for total farm size without Gishwati), and in scenario 2 it will decline by 34 and 30 percent, respectively.

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[21] Following Delepierre (1985), the average yields of maize and sorghum are projected to remain more or less unchanged until the year 2000.

**Table 49—Average production of major crops and total calorie production, 1985-2005**

| Item | Scenario 1[a] | | | Scenario 2[b] | | |
|---|---|---|---|---|---|---|
| | 1985 | 1995 | 2005 | 1985 | 1995 | 2005 |
| | | | (index: | 1985 = 100) | | |
| Development of production | | | | | | |
| Maize | 100 | 106 | 108 | 100 | 106 | 108 |
| Sorghum | 100 | 116 | 124 | 100 | 116 | 124 |
| Beans | 100 | 106 | 112 | 100 | 126 | 148 |
| Peas | 100 | 89 | 82 | 100 | 116 | 122 |
| Potatoes | 100 | 96 | 92 | 100 | 122 | 132 |
| Sweet potatoes | 100 | 125 | 140 | 100 | 164 | 210 |
| Total calorie production (including Gishwati) | 100 | 107 | 111 | 100 | 127 | 131 |
| Total calorie production (without Gishwati) | 100 | 111 | 117 | 100 | 127 | 134 |
| Total calorie production per consumer-equivalent (including Gishwati) | 100 | 73 | 56 | 100 | 86 | 66 |
| Total calorie production per consumer-equivalent (without Gishwati) | 100 | 78 | 61 | 100 | 88 | 70 |

Source: Authors' model projections.

[a] Projections based on endogenous changes in labor intensity and cropping patterns, but not on other technological changes.

[b] Like scenario 1, but with additional technological change for beans, peas, potatoes, and sweet potatoes (2.75 percent a year).

In Table 50, indicators of agricultural labor input, production of major crops, and total calorie production per consumer-equivalent are broken down by the top and bottom person-land-ratio quartiles. Although land productivity in terms of calorie production per hectare and per year is substantially higher (approximately 55 percent) for the top person-land-ratio quartile than it is for the bottom quartile, the table shows that calorie production per consumer-equivalent will decline more drastically for the top quartile in both scenarios (by 2005 to 41 percent and 49 percent, respectively, of the 1985 level).

In both scenarios the average yields of maize in sole stands and of sorghum in intercropping would grow at a rate of 0.4 and 0.3 percent a year, respectively, while the average yield of the maize intercropping system would decline by 1.0 percent a year. For the other crops, only minor changes would occur during the simulation period, with an average yield increase of 0.6 percent a year for peas and 0.3 percent a year for sweet potatoes, and an annual decrease of 0.3 percent for potatoes.

The highest relative increases of crop area would occur for sweet potatoes (+ 32 percent) and for beans (+ 29 percent). On the other hand, the total area devoted to peas would drop by 28 percent during the simulation period.

Changes in the composition of total calorie production by the different crops are more or less negligible for the sample averages and the top person-land-ratio quartile. However, considerable change can be expected even under scenario 1 for the bottom person-land-ratio quartile, which includes the currently more land-rich households. The shares of sweet potatoes will increase substantially in both scenarios in this group, while the contrary applies to the shares of potatoes and peas. Thus the reallocation of the

# Table 50—Average agricultural labor input, production of major crops, and total calorie production per consumer-equivalent, by person-land-ratio quartiles, 1985-2005

| Item | Scenario 1[a] | | | | | | Scenario 2[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | | 1995 | | 2005 | | 1985 | | 1995 | | 2005 | |
| | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile |
| | (index: 1985=100 if not otherwise stated) | | | | | | | | | | | |
| Total agricultural labor input per hectare | 100 | 100 | 108 | 102 | 129 | 100 | 100 | 100 | 108 | 102 | 129 | 100 |
| Production | | | | | | | | | | | | |
| Maize | 100 | 100 | 106 | 100 | 106 | 96 | 100 | 100 | 106 | 100 | 106 | 96 |
| Sorghum | 100 | 100 | 119 | 113 | 144 | 106 | 100 | 100 | 119 | 113 | 144 | 106 |
| Beans | 100 | 100 | 124 | 112 | 138 | 106 | 100 | 100 | 140 | 140 | 162 | 129 |
| Peas | 100 | 100 | 91 | 103 | 74 | 100 | 100 | 100 | 119 | 138 | 98 | 131 |
| Potatoes | 100 | 100 | 95 | 86 | 84 | 79 | 100 | 100 | 121 | 108 | 108 | 99 |
| Sweet potatoes | 100 | 100 | 164 | 113 | 259 | 106 | 100 | 100 | 216 | 148 | 339 | 139 |
| Total calorie production (including Gishwati) | 100 | 100 | 105 | 106 | 108 | 99 | 100 | 100 | 126 | 125 | 130 | 117 |
| Total calorie production (without Gishwati) | 100 | 100 | 114 | 109 | 127 | 102 | 100 | 100 | 127 | 127 | 144 | 119 |
| Total calorie production per consumer-equivalent (including Gishwati) | 100 | 100 | 74 | 63 | 60 | 41 | 100 | 100 | 87 | 74 | 70 | 49 |
| Total calorie production per consumer-equivalent (without Gishwati) | 100 | 100 | 84 | 64 | 78 | 43 | 100 | 100 | 93 | 74 | 88 | 49 |
| Farm size (including Gishwati, hectares) | 1.38 | 0.29 | 1.41 | 0.31 | 1.36 | 0.29 | 1.38 | 0.29 | 1.41 | 0.31 | 1.36 | 0.29 |
| Land productivity (calories/hectare) | 100 | 100 | 102 | 100 | 113 | 99 | 100 | 100 | 121 | 119 | 133 | 117 |
| Labor productivity (calories/person-day) | 100 | 100 | 96 | 98 | 89 | 99 | 100 | 100 | 113 | 116 | 105 | 117 |

Source: Authors' model projections.

[a] Projections based on endogenous changes in labor intensity and cropping patterns, but not on other technological changes.

[b] Like scenario 1, but with additional technological change for beans, peas, potatoes, and sweet potatoes.

available farm land brought about by increasing person-land ratios would lead to higher shares of calorie-dense crops such as sweet potatoes, in particular, and to lower shares of protein-rich crops such as peas and beans.

The development of the labor force available on the household level, the labor input for agricultural work, and (computed as a residual) the potential nonagricultural labor supply in person-days per household and per year are shown in Table 51. The labor force of the sample population increases by 111 percent (3.8 percent a year) during 1985-2005. On the other hand, the agricultural labor input, as derived from model scenario 1, increases by only 21 percent over the 20-year period (1.0 percent a year). As a result, the potential nonagricultural labor supply increases during the simulation period by 4.5 percent a year and, consequently, agriculture's share in the total potential labor force use decreases from 23 to 14 percent.

Hence, while the model predicts an additional labor input of 42 person-days per household (1985 basis) for intensified agricultural labor use, this will absorb only 2.3 percent of the expected increment in the total labor force. Approximately 98 percent of the incremental labor would have to be employed in nonagricultural work—possibly to some extent in home production, but primarily off-farm. Even if the assumed incremental labor supply based on the demographic simulation and the assumed 300 days of work per year per person-equivalent would be somewhat on the high side, this result certainly indicates a great challenge for regional development. Of course, the actual supply of nonagricultural, including home-based, labor might be rather different if the agricultural incomes or nonagricultural income opportunities, or both, should deviate significantly from past trends.

Since women will have a high share in the additional demand for nonagricultural employment, and since social as well as cultural factors tend to limit the scope for off-farm work of women, it will be necessary to create particular new employment opportunities for them in home production and off-farm.

The right-hand part of Table 51 shows the development of the same variables, broken down by person-land-ratio quartiles. As might be expected, the possibility of absorbing the additional labor force by intensifying the agricultural labor input is much more restricted in the top quartile. Consequently, the absolute amount of potential nonagricultural labor supply in person-days per year is much higher in this group.

In the mid-1980s the majority of households were not fully meeting their food-energy requirements out of own food production (86.9 percent, Table 52). As long as other income from agriculture and nonagriculture ensures entitlement to food, a further increase in the share of the population dependent on market supplies is not necessarily a problem. According to both scenarios, the degree of required integration into the food market when land becomes scarcer is expected to be quite high. Average household-level self-sufficiency—expressed in terms of percent of own-produced food energy relative to requirements—would drop until 2005 from 73.8 percent to 37.9 percent in scenario 1 and to 44.8 percent in scenario 2 (with additional technological change). The need for imports into the region thus increases substantially, but whether this need will be backed up by effective demand again depends much on employment generation in agriculture and off-farm as well as on prices and wage-rate development. To create this growth in effective demand, especially in those households that are food-deficit at the outset, remains the main challenge for food security policy.

## Table 51—On- and off-farm labor allocation and distribution, by person-land-ratio quartiles, 1985-2005

| | | | | | Survey Population Quartiles | | | |
|---|---|---|---|---|---|---|---|---|
| | | Total Survey Population | | | 1995[a] | | 2005[a] | |
| Item | Per Household, 1985 | 1985 | 1995[a] | 2005[a] | Bottom Quartile | Top Quartile | Bottom Quartile | Top Quartile |
| | (person-days/ year) | | | (index: 1985=100) | | | | |
| Potential labor force capacity[b] | 856 | 100 | 144 | 211 | 100 | 155 | 189 | 223 |
| | (1.00) | | (1.00) | (1.00) | (1.00) | (1.00) | (1.00) | (1.00) |
| Agricultural labor input | 201 | 100 | 112 | 121 | 111 | 109 | 131 | 102 |
| | (0.23) | | (0.18) | (0.14) | (0.30) | (0.09) | (0.26) | (0.06) |
| Potential nonagricultural labor supply[c] (per household in 1985, and change for total population thereafter) | 655[d] | 100 | 154 | 239 | 155 | 161 | 220 | 239 |
| | (0.77) | | (0.82) | (0.86) | (0.70) | (0.91) | (0.74) | (0.94) |

Source: Authors' model projections.

Note: Figures in parentheses are the shares of the different labor input categories in the potential labor force capacity (first row).

[a] The 1995 and 2005 figures represent the labor supply of the households and their offspring in 1985 sample household averages.

[b] Computed from adult-equivalent persons times 300 days per year.

[c] Including home goods production, such as beer brewing.

[d] It should be noted that this residual potential nonagricultural labor supply includes actual off-farm employment and unemployment time. On average, 96 days of actual employment per household were recorded in 1985 (66 days in the bottom quartile and 88 in the top quartile).

## Table 52—Development of overall food-energy production in relation to minimum requirements at household level, 1985-2005

| Item | Scenario | 1985 | 1995 | 2005 |
|---|---|---|---|---|
| Own food production in percent of requirements of households[a] | 1 | 73.8 | 53.2 | 37.9 |
| | 2 | 73.8 | 62.9 | 44.8 |
| Population not meeting food energy requirements directly out of own production in percent of total population | 1 | 86.9 | 92.4 | 95.1 |
| | 2 | 86.9 | 90.6 | 93.5 |

Source: Authors' simulation results.

[a] Requirements are based on the same energy needs as computed in the food consumption analysis in Chapter 6 (2,798 calories per adult-equivalent person).

## Conclusions from Long-run Simulations

The specific conclusions derived from the analysis of long-run implications of commercialization may be summarized as follows. The majority of farm households in the study region are extremely resource-poor. Taking into account that the farm population will most likely continue to grow at an annual rate of 4 percent, prospects for commercialization through growing more crops for the market are small. The only exception is the special case of potato marketing out of the Gishwati forest. Even if farmers were able to raise their production through further specialization according to comparative advantages, the general tendency of an increasing overall deficit in food would not change. The rural households will more and more depend on food imports from outside the region.

The hypothesis that yields would tend to decline because of the reduction of fallow could not be explicitly supported out of the survey results. Yet, further observations suggest that the projected rates of yield increase resulting from intensified labor input and improved seed and other inputs are indeed rather optimistic. This is indicated not only by the expectation that the overall rate of land use will be further raised, but also because the consequences of past changes in land use (cultivation on steep slopes and reduction of fallow periods) may materialize only in the future, implying a lagged response. However, in relation to the theme of this study, it has to be reemphasized that such negative prospects for soil fertility are not expected to result from increased commercialization but rather from growing population pressure and resulting subsistence needs and lack of improved production technology. This makes it even more urgent to accelerate the development and diffusion of appropriate innovations by research, extension, and market infrastructure. High-priority measures of land conservation would also be needed.

Rapid expansion of sustainable nonagricultural employment opportunities will be the most important precondition for successful socioeconomic development of the region. The survey has revealed that the farm population already spends 50 percent of its total work time on nonagricultural activities, of which one-half is off-farm work. Since a substantial part of the labor capacity appears to be seasonally or even permanently underemployed, this commercialization of family labor could even currently be raised if more jobs were available. The long-run simulations for the next 20 years have shown that the number of nonagricultural jobs will have to be raised to at least twice as high as in 1985 to even maintain current levels of employment. Not only food purchases but also external inputs for agricultural production will have to be paid for out of off-farm incomes.

Currently, nonagricultural employment depends to a considerable degree on jobs that are offered by a few employers, some of which are not established on a long-term basis. One-third of the time worked off-farm by members of the survey households took place in two donor-financed development projects. Another third was spent at the two tea factories that are currently expanding their operations but have been shown to be in a critical economic situation. Thus only one-third of the nonagricultural work is done in a multiplicity of rural activities, partly self-employment in the rural services, partly in government employment. Future policy support of rural employment will have to be much more concerned with this section of the regional labor market. This is not only desirable in order to support the envisaged commercialization of the rural labor force but also to ensure sufficient supplies of local goods and services and thus support rural growth.

# 9

# CONCLUSIONS AND POLICY IMPLICATIONS

This study's focus is on the potentials and constraints of commercialization and technological change for poverty alleviation in an area under severe population pressure. The prevalence of underconsumption and malnutrition is found to be high and persistent in the study area. Land is becoming extremely scarce. Providing for household food security through subsistence food production is less and less a viable option for the majority of households.

Rapid population growth can be a dominating factor in creating and aggravating rural poverty. As Mellor and Desai (1985) point out, "population growth has this deleterious effect through added pressure on employment opportunities which reduce the income flow to labor and through the upward pressure on food prices derived from the additional demand arising from larger population." These basic effects are particularly strong in Rwanda, where little opportunity to reduce population pressure by out-migration exists and where food markets of the landlocked country are volatile and thin due to high transaction costs. Effective policies to reduce population growth are therefore of paramount importance. An accelerated rate of technological change in agriculture to mitigate the income-depressing effect of the high population growth would not, under optimistic assumptions, maintain even the current levels of poverty. Population growth itself needs to be reduced quickly. The required specific actions in education and health services policies are, by now, well understood and are not the focus of this study.

A high prevalence of underconsumption in average years and the 1984 and 1990 famines in Rwanda underscore the severity of the food security problem. Households in rural Rwanda attempt to achieve food security largely by high levels of subsistence production. On average, two-thirds of agricultural production is consumed on-farm. Whereas this farm-based approach to food insurance is feasible for the small and rapidly diminishing group of households with sufficient access to land, it is infeasible for the increasing numbers of land-scarce farm households. In the absence of comprehensive, alternative food-insurance market mechanisms, including credit markets, the poor see no other option for coping with risk than maintaining the highest levels of subsistence food production along with income diversification in the off-farm labor market. The rapidly expanding cultivation of crops that yield high food energy per hectare with low levels of external inputs—especially the sweet potato, identified in this study—is a result of these forces that are driving farmers away from agricultural commercialization. Thus, the poor are too poor to capture the gains from efficient specialization because they need to take care of subsistence-based insurance against hunger.

Given this situation, technological change in the subsistence crops becomes central to household food security. However, as the long-term model scenarios in this study have shown, technical change in subsistence crops alone cannot be the long-term solution: diversification of the rural economy with specialization in agriculture and nonagriculture, fostered by an improved human capital and infrastructure base, must remain the strategic perspective. Achieving employment expansion jointly with increased labor productivity is the challenge.

Long-term analyses suggest an increase of the person-land ratio from 5.5 in 1985 to 12.0 adult-equivalent persons per hectare in the study area in 2005. Most dramatic is the labor supply expansion for nonagricultural employment that will, even under cautious assumptions in the simulations, more than double from its already high levels. Employment needs to be directed toward capital formation in agriculture. Upgrading the agricultural resource base by labor-intensive erosion-control measures such as terracing can be central activities in this context. Public investment for this upgrading is justified because of the conflict between the need of the poor to cope with short-run survival and the long-run sustainability of the resource base for society's food security. Public works activities may play an increasingly important role in this context. Any measures in this field of agricultural resource improvement have to take account of women as the predominant agricultural labor force and of women's time constraints.

Currently, the rural labor market in Rwanda is highly segmented. Women are primarily in agriculture, particularly subsistence crops, whereas men are employed mostly off-farm. The pressure for increased output per unit of land in subsistence cultivation due to increased population pressure will largely fall on women. In principle, technological change in subsistence crops could be expected to directly benefit women's employment, income, and income control. Yet, to the extent that such technological change requires external inputs, women's subsistence focus and related liquidity constraints will hinder technology adoption. For example, potato production with modern inputs is much more a "man's crop" than the traditional subsistence cultivation of the same crop. Tea, however, has opened up employment opportunities for women off-farm. Rapid expansion of women's employment and attention to constraints to adoption of new technologies in subsistence crops are central to women's and children's livelihood in this setting. In support of this conclusion is the finding that incremental women's income translates into incremental household food consumption (calories) over and above the income effect.

The study draws attention to the potential conflict between the concern for (export) diversification of the national economy and household food security. The social costs and benefits of export diversification are not equally distributed, and, in reality, absolute losers were created when tea production—found to be generally a success in Rwanda—was pushed into farm communities that relied heavily on subsistence food for food insurance. Farmers displaced by government tea plantations were found to have a major loss in their assets. Land tenure policy and issues of compensation for asset loss require careful case-specific consideration in the process of commercialization, especially in such land-scarce environments as this study area.

It is not surprising that at the very low levels of income noted at the study site, incremental income goes a long way toward reducing underconsumption and improving child nutritional status. However, malnutrition in this environment is to a very large extent also a health problem that needs to be addressed by the health and sanitation services. The study results highlight the large impacts on child growth that could be achieved by clean latrines, diarrhea control, and cures for intestinal worms. Creation of an effective demand for health services, however, requires household income growth, for which agricultural growth through commercialization and technical change again are instrumental. Thus, public action for health and sanitation in order to reduce malnutrition has to move in tandem with public action to stimulate rural growth through commercialization and technological change in agriculture. In the long run, the sustainability of public services, including health and sanitation services, depends upon the success of the rural growth. In the medium run, development assistance has to provide the bridge.

# APPENDIX 1

# SURVEY DESIGN

As described in the conceptual framework, addressing the research questions requires an integrated approach toward the household production-consumption-nutrition relationships. To empirically fill this conceptual framework, a complex farm household-level data collection was executed in the study area during 1985 and 1986. The survey instruments consisted of the following structured questionnaires to collect information on

A. Household demographics.
B. 1. Food consumption at the household level over one week (during three survey rounds).
   2. Food and nonfood expenditures and use of own-produced food in the household (between the three survey rounds and for extended seasonal recall periods).
C. 1. Health of women (mothers) and their children under age 7.
   2. Nutritional status measures (weight and height of women, men, and children).
D. 1. Agricultural production and crop-use information.
   2. Size of fields (measured or estimated) and certain field characteristics.
   3. Crop yields (in a subsample).
   4. Labor inputs by crop or system (in a subsample).
   5. Basic information on livestock.
   6. Off-farm work and income from all sources.

The precoded questionnaires written in Kinjarwanda for structured interviews were developed and pretested during the second half of 1985. Survey work by a team of enumerators trained during a three-month period in the field was ongoing from December 1985 to October 1986. A team of female enumerators covered questionnaires B and C mentioned above, and a male team covered most of the information in questionnaires A and D.

The actual survey work of the main sample was structured by three separate survey rounds: the first in January-March 1986, the second in May-June 1986, and a third in August-September 1986.

The first survey round included a long-term recall on agricultural production and off-farm income during 1985. The second and third rounds covered the 1985/86 main growing season and the short 1986 season, respectively.

Each survey round consisted of numerous interview sessions, with the respondents (head of household, wife) to the various questionnaire types adjusted to the specific household situation.

To meet the objectives of the research, the sample households were selected in a stratified way, and an attempt was made to arrive at a sample that would cover a significant range of the degrees of commercialization in an area reasonably homogeneous in agroecological terms. As no census-type information is available for the communities, an alternative way of selecting the sample households was chosen, following location-specific stratification.

For reasonable interhousehold comparison, the study area was limited to the high-altitude area.[22] The seven high-altitude *secteurs* of Giciye *commune* were divided into two groups based on their different population densities (population density being related to importance of pasture land, livestock, and other factors). At the same time, this stratification guaranteed that for both groups of *secteurs*, the distance to the Gishwati potato production area as a major source of commercialization was different. From each of these two groups of *secteurs*, two *secteurs* were chosen at random, a selection that resulted in the choice of Gasasa, Birembo, Rubare, and Murambi *secteurs*. Table 53 provides some information on all *secteurs* and the selected ones.

In each of the *secteurs*, two *cellules* were then selected, for a total of eight *cellules*. For this selection, meetings were organized with community leadership of the respective *secteur* and representatives of its *cellules*, in which the latter were asked to indicate, according to their subjective judgments, the importance of certain agricultural products (such as tea, potatoes, livestock) in each *cellule* of the *secteur*. An attempt was made on the basis of these judgments to choose in each *secteur* one *cellule* with a relatively high degree and one with a relatively low degree of commercialization. This selection resulted in the choice of Gasasa (commercialized) and Nyarusongati (less commercialized)

**Table 53—Population density and land use for potatoes and tea in *secteurs* of Giciye *commune*, 1985**

| *Secteur* | Population Density | Average Land/ Household[a] | Share of Potatoes in Land Use | Share of Tea in Land Use |
|---|---|---|---|---|
| | (persons/square kilometer) | (hectares) | (percent) | |
| Birembo[b] | 374 | 1.20 | 19.5 | 0.5 |
| Cyarwa[c] | 919 | 0.50 | ... | ... |
| Gasasa[b] | 595 | 0.77 | 7.7 | 0.7 |
| Gihira[d] | 500 | 0.92 | 7.4 | n.a. |
| Jomba[c] | 406 | 1.13 | 0.8 | ... |
| Kintarure[c] | 432 | 1.07 | ... | ... |
| Murambi[b] | 443 | 1.04 | 1.4 | 1.4 |
| Mutanda[d] | 409 | 1.12 | 4.9 | ... |
| Nyamugeyo[d] | 289 | 1.59 | 8.0 | 0.8 |
| Rubare[b] | 267 | 1.72 | 12.5 | 1.6 |
| Rubona[c] | 531 | 0.87 | ... | ... |
| Shaki[c] | 327 | 1.41 | 0.4 | ... |
| Shyira[c] | 487 | 0.94 | ... | ... |

Source: Records of Giciye *commune*.

Note: n.a. means not available.

[a] This is not actual farm size but area divided by households, including noncultivated or noncultivable land.

[b] *Secteur* in study sample.

[c] *Secteur* not considered for sample random draw because of location in low-altitude zone.

[d] *Secteur* in high-altitude zone but not selected for study.

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[22] In a neighboring low-altitude area, J. Laure (1982) has undertaken a carefully designed case study on the food crop-tea competition and related food-consumption effects.

*cellules* in Gasasa *secteur*, Ruhanga and Muremure in Rubare, Cyugi and Karambi in Birembo, and Gisoro and Ruhunga in Murambi.

Upon the identification of these eight *cellules*, their leaders were requested to provide lists of the names of the heads of households. There was a range of about 85-175 households per *cellule* among these eight *cellules*. From these lists, 22 households were chosen at random per *cellule*, resulting in 176 households.

To permit better assessment of the role of tea, the number of teaholders in the sample was increased. Households in smallholder tea production (*thé villageois*) were chosen at random from the lists of the Rubaya tea factory. This choice was limited to the *secteurs* already sampled. With that constraint, these 22 additional tea households came largely from Murambi *secteur* (both Ruhunga and Gisoro), bringing the total sample size to 198. After a few dropouts, the final count was 192 households. Two households were dropped from the analysis because of enumeration problems.

Finally, a specific group of households was included—those affected by the expropriation of property conducted by OCIR-Thé as part of the expansion of plantation tea at Nyabihu in Karago *commune*. Sampling of these households proceeded as follows. A list of the heads of 58 households affected by the expropriation and still residing in the area was provided by the representatives of the Nyabihu *cellule*.[23] Twenty-one of these households were chosen at random and interviewed with a simple expropriation and general identification questionnaire. Of these 21 households, 3 were chosen at random from households with no small children and 5 at random with small children. These 8 households responded to questions approximating one round of the main study in Giciye *commune*. Together with a group of displaced farmers who were captured by the main sample in the surroundings of the Rubaya tea factory, a total of 32 such displaced farm households are included in the survey.

To sum up, sample selection criteria were altitude zone (*commune* level), population density (*secteur* level), and degree of commercialization (*cellule* level). This sample was supplemented by small samples of households in smallholder tea and farm households expropriated because of factory tea expansion.

Additional data collection was done at market level (prices) and on various production activities (for example, beer brewing) at household level in subsamples.

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[23] The number of displaced farmers totaled 450. The area of plantation tea established on land of displaced farmers was approximately 300 hectares, according to information provided by Nyabihu factory management.

# APPENDIX 2

# SUPPLEMENTARY TABLES

Table 54—Age-specific birth rates of Gisenyi *prefecture*, 1983

| Age Group | Live Births per 1,000 Females |
|---|---|
| 15-19 | 59 |
| 20-24 | 340 |
| 25-29 | 430 |
| 30-34 | 408 |
| 35-39 | 342 |
| 40-44 | 224 |
| 45-49 | 110 |

Source: Rwanda, National Population Office, *Enquête nationale sur la fécondité* (version résumée et version complète) (Kigali: NPO, 1985).

Table 55—Death rates by sex and age cohorts used for the demographic model

| Age Cohort | Male | Female |
|---|---|---|
| 0-4 | 0.22 | 0.22 |
| 5-9 | 0.06 | 0.06 |
| 10-14 | 0.001 | 0.0082 |
| 15-19 | 0.0372 | 0.0311 |
| 20-24 | 0.0391 | 0.0253 |
| 25-29 | 0.0186 | 0.0151 |
| 30-34 | 0.0136 | 0.0271 |
| 35-39 | 0.0018 | 0.0126 |
| 40-44 | 0.0058 | 0.0456 |
| 45-49 | 0.0250 | 0.0300 |
| 50-54 | 0.0090 | 0.0019 |
| 55-59 | 0.0132 | 0.0216 |
| Above 59 | 0.0770 | 0.0136 |

Source: Authors' computations from the distribution of the total Rwandan population in 1978 and 1983 in Rwanda, National Population Office, *Enquête nationale sur la fécondité* (version résumée et version complète) (Kigali: NPO, 1985).

## Table 56—Coefficients used to calculate the number of adult-equivalent persons

| Age Group[a] | Coefficient |
|---|---|
| 5-9 | 0.1 |
| 10-14 | 0.2 |
| 15-54 | 1.0 |
| 55-59 | 0.6 |
| 60-69 | 0.47[b] |

[a] Male and female.

[b] This coefficient has been derived by multiplying the share of persons of this age group in the total population above 60 years of age by 0.6.

## Table 57—Coefficients used to calculate the number of consumer-equivalents

| Age Group | Male | Female |
|---|---|---|
| 0-4 | 0.20 | 0.20 |
| 5-9 | 0.50 | 0.50 |
| 10-14 | 0.75 | 0.70 |
| Above 14 | 1.00 | 0.75 |

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RESEARCH REPORT

86

# THE EFFECTS OF INTERNATIONAL REMITTANCES ON POVERTY, INEQUALITY, AND DEVELOPMENT IN RURAL EGYPT

Richard H. Adams, Jr.

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Richard H. Adams, Jr.

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# FOREWORD

Many low-income people, especially those from poor rural areas, seek to improve their lives by migrating in search of work and income, increasingly moving across national borders and farther afield. In recent years, the remittances they earn have come to have an important effect on the economies of many developing countries, profoundly affecting poverty, income distribution, and rural economic development in the villages from which they migrated.

The results of this study complement the findings of other IFPRI studies on poverty alleviation, income sources, and rural development. The study uses primary household data from a small area of rural Egypt in an innovative way to address such vital questions as who migrates, how remittances affect poverty and income inequality in the receiving villages, and how spending by returning migrants facilitates local development. The finding of this study that the rural poor, who actively participate in international migration, tend to invest their remittance earnings rather than spending on own or family consumption has broad implications for policy planning of countries that send many migrants abroad.

Just Faaland

Washington, D.C.
May 1991

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Early encouragement came from John Mellor, the former director of IFPRI. Field research for the project was supported in part by a 1986-87 fellowship grant from the American Research Center in Egypt (ARCE).

Collection and analysis of the field data for this report would have been impossible without the efforts of two people. Mohammed Shaaban efficiently supervised data collection in rural Egypt, and Jane He painstakingly pursued computer analysis in Washington.

Early advice from two IFPRI colleagues, Harold Alderman and Howarth Bouis, did much to focus the analysis. Joachim von Braun, John Hoddinott, D. Gale Johnson, and Ahmed el-Miniawy also offered useful suggestions on initial parts of this research. In the final stage, the comments of Albert Berry, Michael Lipton, Richard Sabot, and an anonymous reviewer helped to significantly improve the contents of the report.

However, perhaps the most important acknowledgment should go to the inhabitants of the surveyed households in Minya Governorate. Without the assistance and cooperation of these villagers, this report would have never seen the light of day.

# 1

# SUMMARY

International remittances—the money and goods transmitted to households back home by people working away from their origin communities—can have a profound effect on poverty, income distribution, and development in rural areas of Third World countries. This study examines the effects of international remittances on rural Egypt, where international migration has been extensive in recent years. It is based on a household survey conducted in 1986/87 in three villages in Minya Governorate, a rural province about 250 kilometers south of Cairo.

The survey included two rounds of random interviewing in different census blocks in the villages. In the first round, data were collected on the socioeconomic characteristics and migration experiences of 1,000 households, and in the second round, detailed information was collected on the expenditure behavior of 75 returned (once-abroad) migrant and 75 nonmigrant households.

The rate of international migration in the survey area is high: 339 out of 1,000 surveyed households sent someone to work abroad in the 10 years prior to the survey (1976-86). Of these 339 migrant households, 235 households had a migrant who had returned from abroad and 104 had a migrant who was still working abroad. Most of the migrants went to work in one of the neighboring Arab oil countries—Iraq, Kuwait, Libya, or Saudi Arabia.

International remittances are defined here as all transfers of money and goods from international workers. Travel and basic subsistence costs (for food and housing) abroad are excluded. These remittances play an important role in the economies of the surveyed households, accounting for 12.5 percent of total actual gross income of the 1,000 households and for 30.4 percent of total actual gross income of the 339 households with migrants, including both once-abroad and still-abroad migrants.

The study examines the social and economic determinants of international migration within the context of migration and human capital models of development. These models suggest that younger and better-educated people choose to migrate because earning possibilities differ in spatially separated labor markets. In analyzing why certain workers migrate, variables such as age, marital status, employment, education, age of household head, amount of land farmed, and predicted per capita household income (excluding remittances) are considered. The variables marital status, employment (agricultural laborer), and education (above elementary) are positively related to the decision to work abroad, whereas the influence of all the other variables is negative.

In evaluating the impact of international remittances on poverty and income distribution, the study uses predicted income equations to estimate the changes that occur between two situations: excluding remittances, where the remittances of the 104 households with a still-abroad migrant are excluded, and including remittances, where the remittances of these still-abroad migrants are included.

Using this framework, the study finds that international remittances have a small but positive effect on poverty. The results indicate that the number of households living in poverty declines by 9.8 percent when predicted per capita household income (estimated household income divided by the number of family members) includes remittances from the 104 still-abroad migrant households. Similarly, Sen's index of poverty suggests that poverty falls by 12 percent when predicted per capita household income includes remittances.

These changes in poverty are a reflection of the small—but proportionate—number of poor households actually receiving international remittances. According to the data, 28 of 268 households (10.4 percent) classified as "poor" when remittances are excluded receive remittances. In the sample as a whole, exactly the same proportion of households—10.4 percent—receive remittances. Clearly, poor households can and do produce international migrants.

Although international remittances have a positive effect on poverty, they have a *negative* effect on income distribution. When remittances are included in predicted per capita household income, inequality increases. The reasons for this paradoxical outcome are several. When remittances are included, the lowest income quintile produces its proportionate share of still-abroad migrants, but the second and third income quintiles do not. Moreover, when remittances are included, the two top income quintiles produce more than a proportionate share of still-abroad migrants. It is these variations in the number of migrants produced by different income groups—and not differences in either migrant earnings abroad or marginal propensities to remit—that cause international remittances to have a negative effect on rural income distribution.

It should, however, be emphasized that adverse effects on income distribution are not inevitable. The effect of remittances on income distribution was negative because at the time of the survey most of the still-abroad migrants were from the upper-income groups. Among the once-abroad category of migrants, however, just as many migrants came from poor and lower-middle-income households as came from upper-income households. Had the households sending migrants abroad been evenly distributed at the time of the survey, it is likely that the impact of remittances on rural income distribution would also have been more equitable.

In evaluating the economic uses of international remittances, the study compares the expenditure patterns of 75 once-abroad migrant and 75 nonmigrant households. Contrary to popular belief, the data show that once-abroad migrants do not devote large shares of their remittance earnings to personal consumption (food, clothing, schooling, medical, pilgrimage, and marriage expenses). Using expenditure data and controlling for level of expenditure, marginal budget shares devoted to consumption are higher for nonmigrant households in all but one quintile. Migrant households tend to view their remittance earnings as a temporary income stream not to be spent on newly desired consumer goods.

Once-abroad migrant households tend to spend the bulk of their remittance earnings on housing. Fully 53.9 percent of actual remittance expenditures on nonrecurring items went to the construction or repair of houses. In the classification system used in this analysis, which divides expenditure into consumption, durables, and investment, expenditures on housing dominate the category of durables (housing and household goods).

Once-abroad migrant households also have a higher marginal propensity than nonmigrants to allocate expenditures to investments such as land, agricultural equipment, vehicles, and small businesses. This finding contradicts the widespread belief that migrants do not invest their remittance earnings. Controlling for level of expenditure, marginal budget shares to investment are consistently higher for once-abroad migrants than for nonmigrants. Most of this investment goes to land. Approximately 73 percent of total per capita expenditure on investment by once-abroad migrant households goes to the purchase of agricultural land or to land for building. From the standpoint of the migrant, land represents a good investment because the value of land tends to keep pace with the rate of inflation.

# 2

# RESEARCH ISSUES, APPROACH, AND METHODOLOGY

## Remittances and the Local Economy

International remittances refer to money and goods that are transmitted to households back home by people working away from their origin communities. In many cases, such resource transfers can have a profound impact on poverty, income distribution, and economic development in rural areas of the Third World (Stark 1980; Cox and Jimenez 1990). In developing countries, most poor people live and work in the countryside. Rural incomes tend to be lower than incomes earned in either the urban sector or abroad. It is this disparity between rural incomes and expected incomes elsewhere that causes rural residents to migrate—either to urban areas or abroad.

From the standpoint of poverty and equity concerns, the main question regarding international remittances is who migrates. Are migrants drawn primarily from upper or lower rural income groups? If migrants are drawn from wealthier rural groups, this may have important negative effects on income distribution and political stability in the countryside. For example, a sharp increase in rural income inequalities may shorten the life of an unpopular ruling elite.

From the standpoint of economic development, the question of who migrates needs to be coupled with another issue: how do migrants use their monies? Do international migrants channel their remittances into productive investments in their rural communities, or do they use such monies to underwrite the consumption of newly desired consumer goods? Stated more baldly, do international remittances help provide the investment needed to facilitate development, or do they merely foster new patterns of dependency on "status-oriented" consumer goods?[1]

Despite the importance of these issues, there is still no general agreement about the effects of worker remittances on Third World rural areas. Even when these remittances are quite large—as they often are for international migrants working in Europe or the Middle East—there is no consensus on the effects of these earnings on rural poverty, income distribution, and development.

Two main methodological problems account for this lack of consensus on remittances: the use of local-level data collection techniques that preclude making unambiguous empirical judgments about the impact of remittances, and the reluctance or inability to use predicted income functions to accurately estimate income before and after migration.

This study attempts to overcome these and similar problems by proposing a framework and techniques for analyzing the first-order effects of remittances on one rural Third World area. The area under analysis represents a useful case study because in recent years large numbers of rural Egyptians have gone to work abroad. According to official sources, at the time of the study (1986/87) about 3 million Egyptians (17 percent of the total labor force) were working abroad. Many of these Egyptians went to work in Arab oil-rich countries such as Iraq, Kuwait, and Saudi Arabia.

---

[1] The allocation of remittances between investment and consumption will, of course, be influenced by the private rates of return on such investments. See Chapter 6.

Official remittances from Egyptian migrant workers increased from essentially zero in 1971 to US$3 billion in 1985/86 (Table 1). This figure probably underestimates the tremendous rate of increase in international remittances in Egypt, inasmuch as a large amount of such income (possibly US$1 billion) enters the country in a way that is not counted. Throughout the 1980s international remittances (official and unofficial) represented the single most important source of foreign exchange in Egypt.

In more recent years, and especially since the 1991 Persian Gulf crisis, news reports have suggested that the number of Egyptians working abroad, especially in Iraq and Kuwait, has fallen.[2] However, as these two oil-rich countries begin the long process of reconstruction, the demand for Egyptian migrants is likely to reach new historic levels. This situation, coupled with the opening of new employment opportunities in Saudi Arabia, is likely to keep Egypt a major labor exporter well into the next century. Indeed, the figures in Table 1 show that between 1985/86 and 1988/89 official worker remittances flowing into Egypt actually *increased* to US$3.5 billion.

There are, unfortunately, no data available concerning the proportion of these international remittances that has gone to rural—as opposed to urban—Egyptian households. However, according to one government study, about 40 percent of the Egyptian labor force is engaged in agriculture (Egypt, Central Agency for Public Mobilization and Statistics 1979). If it is assumed that 40 percent of all Egyptians working abroad also come from the agricultural sector, and that their total overseas earnings are either proportional or slightly less than proportional to their numbers, it seems reasonable to conclude that at the time of this study rural Egyptians were remitting between US$600 million and US$1,200 million a year.

## Study Area and Sampling

Data for the study came from a household survey conducted by the author between September of 1986 and May of 1987 in rural Egypt. The survey included three villages in Minya Governorate, a rural province about 250 kilometers south of Cairo. Given the lack of existing information about the role of remittances in rural life, these villages were *not* selected on the basis of purported migration characteristics[3] or on any other basis that might lead one to consider them "representative" of rural Egypt as a whole. The villages were chosen because they were the ones that the author had studied in 1978-80 (Adams 1986). Although the results of this study are not generalizable for rural Egypt as a whole, they are indicative of the effects of international remittances in one specific rural Egyptian locale.

The survey area is located far from major urban areas; it is largely rural and agricultural. According to survey data, approximately 46 percent of the male work force

---

[2] See, for example, the *New York Times*, September 4, 1990.

[3] In fact, when the author announced his desire to study international remittances in these three villages, several local informants advised him "to go elsewhere" because they felt that there "were so few migrants" in this area!

## Table 1—Sources of foreign exchange in Egypt, 1971-1988/89

| Source | 1971 | 1975 | 1980 | 1985/86 | 1988/89 |
|---|---|---|---|---|---|
| | | | (US$ million) | | |
| International remittances[a] | 0 | 400 | 2,700 | 3,000 | 3,500 |
| Petroleum exports | 0 | 200 | 3,000 | 2,200 | 1,200 |
| Other exports | 900 | 1,400 | 1,100 | 1,200 | 1,500 |
| Suez canal | 0 | 100 | 700 | 1,000 | 1,300 |
| Tourism | 100 | 400 | 700 | 800 | 2,000 |
| Other receipts | 100 | 300 | 1,200 | 2,200 | 3,200 |
| Total | 1,100 | 2,800 | 9,400 | 10,400 | 12,700 |

Sources: Data from annual reports of the Central Bank of Egypt, in David W. Carr, "The Possibility of Rapid Adjustment to Severe Budget-Deficit and Other Economic Problems in Egypt," *Journal of Developing Areas* 24 (January 1990): Table 1.

[a] International remittance figures include both monetary transfers to banks and exchange imports of Egyptians working abroad. As noted in the text, these official remittance figures probably underestimate the actual level of remittances entering Egypt in any given year.

are peasant farmers (see Table 2). Most of these farmers rent or own small plots of land, which average about 0.90 feddan (1 feddan = 1.038 acre). Smaller percentages of the male labor force in the area are employed as government employees (17 percent), artisans (7 percent), or agricultural laborers (7 percent).

The survey included two rounds of interviewing. In the first round, 1,000 households in the three villages were interviewed to collect basic socioeconomic data on each household member including age, education, primary and secondary occupations, and contribution of each member to gross household income. Data were also gathered on household landowning status, rental income, and the presence of any household member who had worked abroad at any time during the 10-year period 1976-86.

On the basis of the first round of the survey, the 1,000 households are divided into three groups: nonmigrant (661 households), once-abroad migrant (235), and still-abroad migrant (104). Each group is then stratified (from high to low) on the basis of actual gross household income. For nonmigrant and once-abroad migrant households, actual gross household income is calculated as the sum of all individual incomes; if individual incomes were earned in agriculture, they include an imputation for home-consumed goods. For still-abroad migrant households, actual gross household income includes the sum of all individual incomes plus remittances of still-abroad migrants valued as follows.

For each still-abroad migrant, total income abroad equals the monthly income earned abroad multiplied by the total number of months abroad. Remittances are then calculated as

$$\begin{aligned} \text{Remittances} = {} & (\text{Total income abroad}) \\ & - [(\text{Travel costs abroad}) \\ & + (\text{Housing costs abroad}) \\ & + (\text{Food costs abroad})]. \end{aligned} \tag{1}$$

Remittances include both money and goods earned by the still-abroad migrant. A portion has, of course, already been sent home by the still-abroad migrant; in the static assumptions of this study, the remainder is also treated as having been sent home. Since

## Table 2—Summary of characteristics of all households and migrant households, 1986/87 survey

| | |
|---|---|
| All households | |
| Number of households | 1,000 |
| Mean family size | 6.8 |
| Total number of males 18 years or older | 1,859 |
| Mean land farmed (rented and owned) (feddans)[a] | 0.9 |
| Occupational status of all males over 18 years (percent) | |
| Farmer/peasant | 46.3 |
| Government worker | 17.0 |
| Artisan | 6.9 |
| Merchant | 5.2 |
| Agricultural laborer | 6.9 |
| Professional | 2.6 |
| Private sector worker | 1.0 |
| Student | 6.8 |
| Unemployed | 5.2 |
| Retired | 2.0 |
| Actual mean gross income per month (including remittances) of all households in LE[b] | 225.9 |
| Share of international remittances in total actual gross household income (percent) | 12.5 |
| All migrant households | |
| Number of households with migrants ever abroad | 339 |
| Number of households with migrants still abroad | 104 |
| Number of total individual migrants | 363 |
| Mean age of all migrants (years)[c] | 33.3 |
| Marital status of all migrants (married = 100, unmarried = 0) | 78.8 |
| Mean land farmed (rented and owned) of all migrant households (feddans)[a] | 0.7 |
| Average time spent abroad (years) | 2.1 |
| Occupational status in Egypt of all migrants (percent) | |
| Farmer/peasant | 49.0 |
| Government worker | 18.4 |
| Artisan | 9.4 |
| Merchant | 4.4 |
| Agricultural laborer | 15.4 |
| Professional | 2.2 |
| Private sector worker | None |
| Student | 0.3 |
| Unemployed | 0.6 |
| Retired | 0.3 |
| Actual mean gross income per month (including remittances) of all migrant households in LE[b] | 273.0 |
| Share of international remittances in total actual gross household income of households with migrants (percent) | 30.4 |

Source: Richard H. Adams, Jr., "Worker Remittances and Inequality in Rural Egypt," *Economic Development and Cultural Change* 38 (October 1989): Table 1.

[a] 1 feddan = 1.038 acres

[b] LE 1 = US$0.73.

[c] This indicates the age of migrants at the time of migration.

savings held abroad by still-abroad migrants are minimal, these are also included in remittances.

In the second round of the survey, 150 of the original 1,000 households were selected for interviewing: 75 from the income-stratified group of nonmigrant households and 75 from the income-stratified group of once-abroad migrant households.[4] None of the households in the still-abroad migrant group were chosen for interviewing in the second round because it seemed desirable to question migrants themselves regarding remittance expenditures. The goal here was to select two comparable groups of income-stratified migrant and nonmigrant households so that the main difference between them was that of receiving remittances or not.

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[4] For details on how the 150 households in round 2 were selected, see footnote 36 in Chapter 6.

Two aspects of these household surveys need to be noted. First, according to social tradition in this area of rural Egypt, it is considered "shameful" for women to work outside of the household. Few females are thus engaged in outside remunerative employment, and those who are, are reluctant to admit it. In the survey this led to an underreporting of the female contribution to gross household income, a problem not unknown to surveys in other Third World countries. Second, in order to enhance data accuracy, several checks were done in the field. After they were collected, all data—and especially those on migration, occupation, income, and landholding—were reviewed by local leaders in each of the three villages. These checks helped pinpoint discrepancies and omissions in the data, problems that were then corrected by a return visit to the household in question.

## Methodology

Because of the tremendous volume of international remittances in rural Egypt, this study examines only the impact of *international* (and not internal) remittances on poverty, income distribution, and development. Although migrants from any given rural area may well be working in Egyptian cities such as Cairo and Alexandria, at present the largest income gains are made by those villagers who go to work abroad. Moreover, this study focuses on the direct, first-order effects of remittances. This means that the study largely ignores the second- and third-order effects of remittances on employment, wages, and production.[5] Given the confusion that surrounds evaluating the first-order effects of remittances, it seemed advisable to limit the scope of the analysis.

The study examines three separate relationships. Since the analysis of each of these relationships uses a different subset of the sample population, it is useful to set out the general features of the three econometric models.

The first model specifies the socioeconomic determinants of international migration. It includes data on all males over 18 years of age in the sample (N=1,859). The dependent variable is a dichotomous variable (migrant/nonmigrant), hypothesized as a function of the following variables:

Migrant/Nonmigrant = f (Age, Marital status, Employment, Education,
Age of household head, Land farmed, Males over 13
years in household, Predicted household income,
Agriculturalists in village, Distance of village). (2)

The second model analyzes the first-order effects of remittances on poverty and income distribution. In this model selected parameters of nonmigrant households are used to predict (that is, estimate) the incomes, excluding remittances, of all once-abroad and still-abroad migrant households in round 1. Then, to be consistent in the treatment of incomes, incomes are also predicted including remittances. Because of methodological problems associated with evaluating at what point in time the 235 households with a once-abroad migrant received their remittances, the overseas earnings of these once-abroad migrants are *not* included here. The following equations are used:

---

[5] Unfortunately, few works analyze the second- and third-order effects of remittances on employment and production. Notable exceptions are Taylor (1986) and Stahl and Habib (1989).

Predicted income (excluding remittances) = f (Land, Education, Household size, Males over 13 years in household), and (3)

Predicted income (including remittances) = f (Land, Education, Household size, Males over 13 years in household, Migration dummy). (4)

The third model analyzes the economic uses of remittances by using data from round 2 to compare the expenditure patterns of 75 nonmigrant households with those of 75 once-abroad households. In this analysis the expenditure patterns of still-abroad households are *not* considered, since it seemed best to interview migrants in person regarding how they spent their remittances. In this model the expenditure patterns of nonmigrant and once-abroad migrant households are compared using the equation,

Consumption/expenditure = f (Expenditure, Household size, Months abroad, Migration dummy). (5)

This overview of methodology is intended to be general. Additional variables used in each model will be discussed more specifically when the regression equations are presented.

## 3

# WHO GOES TO WORK ABROAD?

The impact of international remittances on the rural economy depends on answers to three questions. Who goes to work abroad? How much do different income groups of migrants earn abroad? And what is their propensity to remit?

Of these questions, the first is the most basic. Analyzing the structure of migration provides the means for evaluating the effects on the rural economy of both the earnings of migrants and their propensity to remit. This chapter therefore focuses on the structure of international migration by analyzing its social and economic determinants within the context of migration and human capital models of development. Issues relating to migrant earnings and propensities to remit will be analyzed in Chapter 4.

One widely accepted theory of migration in developing countries comes from the Harris and Todaro (1970) hypothesis that individual migration decisions are based on differential expected incomes. According to this model, people choose to migrate because earning possibilities differ in spatially separated labor markets. In recent years various studies have attempted to empirically test the relevance of the Harris and Todaro model. These efforts can be broadly classified in two ways.

First, some economists have tried to explain migration by focusing on the "pull" of differential wage rates in various regions of a developing country (House and Rempel 1980; Falaris 1979; Carvajal and Geithman 1974). In these analyses the rate of internal migration within a country is typically related to aggregate characteristics of areas of origin (rural) and destination (urban), variables such as average wage, education, and employment rates. These studies encounter several problems,[6] most notably that of data aggregation. Whereas the explanatory variables in these studies relate to the total population of a particular region, Harris and Todaro recognize that migration is an individual decision made on the basis of the income that a worker expects to receive given his or her specific human capital characteristics, such as education, age, and skills. The use of aggregate census data thus tends to mask—and even obscure—critical parts of the migration decisionmaking process.

Second, in an attempt to give renewed attention to the "push" factors involved in migration, some economic demographers have begun to focus on origin areas. Whereas past efforts to test migration models have relied mainly on data gathered in destination areas, in the last five years new efforts have been directed to collecting and analyzing data gathered in rural origin areas (Bilsborrow et al. 1987; Brown and Goetz 1987; Findley 1987). Such studies have tried to relate migration to a host of individual-, household-, and community-level variables such as education, employment, family size, land farmed, and distance from urban areas. Although illuminating, these origin-level studies all fail to analyze what might be considered the *key* economic variable in any migration decision, namely, income or earnings. Without information on income in either the area of origin or destination, these studies cannot be used to test the purely economic rationale behind individual migration decisions.

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[6] For a more complete list of such problems, see DaVanzo (1981, 98-100).

To overcome problems encountered in these earlier studies, a new framework is proposed here for analyzing the economic and demographic determinants of migration. First, predicted income functions are used to establish income before migration (income excluding remittances). Predicted income is then incorporated into a migration model as an individual rather than an aggregate variable, thus shedding light on the economic motivations for migration. Second, data from origin areas, collected in rural Egypt, are used to specify and estimate a model of migration that includes individual, household, and community variables. By using origin-area data on such variables as age, education, and employment, the study seeks to advance understanding of the human capital components of migration.

After summarizing the statistics from the survey and comparing characteristics of migrant and nonmigrant households, this chapter presents the predicted income functions used for identifying origin income. Finally, it specifies and estimates the migration model and presents the results.

## Descriptive Statistics on and Characteristics of Migrants

Of the 1,000 households surveyed, 339 households, or 33.9 percent, reported that a household member had gone to work abroad during the 10 years prior to the survey (Table 2). Because this survey focused on migration, the recorded rate of international migration is much higher than that reported by other studies in rural Egypt to which migration data were incidental.[7] Of the 339 migrant households, 235 households had migrants who had returned home and 104 households had migrants still working abroad.

All of the international migrants in the sample were male; not a single female migrant was recorded. The overwhelming majority went to work in a neighboring Arab oil country. Seventy-four percent went to Iraq because at the time of the study Iraq did not impose any visa or work restrictions on Egyptian laborers. During the period of this study international migration from rural Egypt was essentially a supply-side phenomenon. This means that virtually any Egyptian villager who could meet the travel costs—about 500 Egyptian pounds (LE) (US$365)—and opportunity costs of international migration could, in effect, migrate. After a month or two of searching for work in Iraq, migrants could usually find an unskilled position in construction or agriculture. Smaller numbers went to Kuwait, Libya, or Saudi Arabia.

Because the volume of international migration is so high in the 1,000 households surveyed, remittances play a critical role in their economies. The share of remittances in total actual gross household income for all 1,000 households is 12.5 percent (Table 2). For migrant households, such remittances account for 30.4 percent of total actual gross income. These figures are not surprising. At the time of the survey, a village migrant working abroad in an Arab oil country could easily gross three-to-four times more per month than he could working in rural Egypt. During 1986/87 the mean monthly wage for a landless agricultural worker in the study area was LE 90 (US$65). Working abroad, that same worker could earn an average gross monthly wage of LE 350 (US$255).

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[7] In his village study in Asyut Governorate, Hopkins (1983, 1987) found that 10 percent of households had a history of working abroad. In another study of three villages in the Egyptian Delta, Commander and Hadhoud (1986, 163) reported that 7-10 percent of households had an international migrant.

## Table 3—Selected characteristics of migrant and nonmigrant households, 1986/87 survey

| Item | Nonmigrant Households (N = 661) | Migrant Households[a] (N = 339) | t-Statistic (Two-Tailed) |
|---|---|---|---|
| Mean household size | 6.55 | 7.38 | 4.03** |
| Mean number of males over 13 years old in household | 2.11 | 2.57 | 5.34** |
| Mean number of females over 13 years old in household | 1.91 | 2.04 | 1.88* |
| Mean education of males over 18 years old in household (one if preparatory school or higher, zero otherwise) | 0.18 | 0.23 | 2.28** |
| Mean land farmed[b] (feddans)[c] | 1.07 | 0.72 | -1.91* |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

[a] Includes households with either once-abroad or still-abroad migrants.

[b] Includes land rented and owned.

[c] 1 feddan = 1.038 acres.

*Difference between households is significant at the .10 level.

**Difference between households is significant at the .05 level.

Selected characteristics of migrant and nonmigrant households are compared in Table 3. Households with migrants are significantly larger on average (7.38 persons) than households without migrants (6.55 persons), and they have significantly more males over 13 years of age (2.57 compared with 2.11).

Households with migrants also farm significantly less land (rented and owned)[8] than households without migrants. This suggests that migrant households are poorer. Although this point will be investigated in more detail later, it is important to pinpoint here the relationship between land and income. In the Egyptian countryside land generates only about half of total income.[9] This means that in any given village there are many Egyptians who do not need land to survive because they are employed outside of agriculture as government workers, artisans, and merchants. For example, only 43 percent of the households in this sample are primarily engaged in agriculture; agricultural income provides only 55 percent of total actual gross household income. Therefore, land represents an important income-generating asset in the Egyptian countryside, but it is not the only asset.

The age distribution of males over 18 years old in the sample shows that the highest percentage of migrants is concentrated in the 21-30 age category (Table 4). The mean age of migrants is lower than that of nonmigrants (31.3 versus 37.6 years), and this difference is significantly different from zero at the 5 percent level. These results are consistent with the findings of other researchers in Egypt (Fergany 1984; Khafagi 1983). They are also consistent with the hypothesis of migration theory that predicts that, in

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[8] In rural Egypt, government regulations regarding land tenancy are so structured that a tenant possessing a valid, written rental contract virtually "owns" the land that he rents (Adams 1986, 90).

[9] In their 1977 study of 1,000 rural Egyptian households, Radwan and Lee found that "only 50 percent of total household income is derived from agriculture" (1986, 31).

## Table 4—Distribution by age of males over 18 years old, migrants and nonmigrants, 1986/87 survey

| Age[a] | Percent of Individual Migrants[b] (N = 363) | Percent of Individual Nonmigrants (N = 1,496) |
|---|---|---|
| Under 20 | 8.0 | 17.3 |
| 21-30 | 47.9 | 27.1 |
| 31-40 | 26.4 | 17.3 |
| 41-50 | 14.0 | 15.1 |
| 51-60 | 2.8 | 13.3 |
| Over 60 | 0.8 | 9.9 |
| Total | 100.0 | 100.0 |
| Mean age (years) | 31.3 | 37.6 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: N = 1,859. These figures are for individual migrants, not households.

[a] Indicates the ages of migrants at the time of migration.

[b] Includes both once-abroad and still-abroad migrants.

general, age will be inversely correlated with migration, since younger migrants enjoy greater lifetime returns to migration and lower relocation costs.

When the educational statuses of males over 18 years of age in the sample are compared (Table 5), the results are surprising because they do not indicate the degree of educational selectivity that is predicted by the human capital model of migration. According to that model, educated people are more likely to migrate. However, the data here suggest that at the lower levels of education, there is very little difference between migrant and nonmigrant groups. Whereas 74.9 percent of the migrants are illiterate or can only read and write simple phrases, 77.6 percent of nonmigrants also fall in this

## Table 5—Distribution by education of males over 18 years old, migrants and nonmigrants, 1986/87 survey

| Educational Level[a] | Percent of Individual Migrants[b] (N = 363) | Percent of Individual Nonmigrants (N = 1,496) |
|---|---|---|
| Illiterate | 58.1 | 59.6 |
| Read/write | 16.8 | 18.0 |
| Elementary school | 0.6 | 1.0 |
| Preparatory school | 0.8 | 1.4 |
| High school | 20.7 | 14.4 |
| University | 1.9 | 4.9 |
| Other | 1.1 | 0.6 |
| Total | 100.0 | 100.0 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: N = 1,859. These figures are for individuals, not households. Numbers may not add to totals due to rounding.

[a] Indicates the educational level of migrants at the time of migration.

[b] Includes once-abroad and still-abroad migrants.

category. Only at the higher levels of education—especially at the high school level—are there more migrants than nonmigrants—20.7 percent of the migrants have received a high school education compared with only 14.4 percent of nonmigrants.

Although it is difficult to explain the lack of educational selectivity shown in Table 5, it is possible to identify some reasons why high school graduates are more likely to migrate. In the Egyptian countryside the private sector is quite weak, which means that most educated people seek work with the government. But they must often wait four to five years after graduation to be assigned to a government post, so many of them choose to work abroad in the interim. A careful examination of Table 5, however, suggests that it is mainly high-school-educated males who exercise this overseas work option: the percentage of university-educated migrants (1.9 percent) is smaller than that for similarly educated nonmigrants (4.9 percent).

The premigration occupational distribution of males over 18 years of age in Table 6 is again not wholly consistent with migration theory. While that theory hypothesizes the migration of the more skilled, the data in Table 6 indicate little evidence of occupational selectivity. For instance, whereas 49 percent of all migrants work as farmers/peasants, 45.7 percent of nonmigrants fall into this category. Of all the occupational groups listed in Table 6, only one— agricultural laborers—produces a disproportionately high share of migrants. However, agricultural laborers are generally among the *least* skilled: 78 percent of agricultural laborers in the sample are illiterate. This finding is thus quite paradoxical in that it suggests that less education is actually associated with more migration. Such an outcome is the opposite of what one would expect from migration and human capital theory and will be investigated more fully below.

The distribution of landholdings between the two groups of households is generally similar (Table 7). For example, the percentage of migrant households that are landless (60.5 percent) is close to the percentage of nonmigrant households in this category (56.4

**Table 6—Distribution by occupation of males over 18 years old, migrants and nonmigrants, 1986/87 survey**

| Occupation[a] | Percent of Individual Migrants[b] (N = 363) | Percent of Individual Nonmigrants (N = 1,496) |
|---|---|---|
| Farmer/peasant | 49.0 | 45.7 |
| Government worker | 18.5 | 16.6 |
| Agricultural laborer | 15.4 | 4.8 |
| Artisan | 9.4 | 6.4 |
| Merchant | 4.4 | 5.4 |
| Professional | 2.2 | 2.7 |
| Private-sector worker | . . . | 1.3 |
| Unemployed | 0.6 | 6.4 |
| Student | 0.3 | 8.4 |
| Retired | 0.3 | 2.4 |
| Total | 100.0 | 100.0 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: N = 1,859. These figures are for individuals, not households. Numbers may not add to totals due to rounding.

[a] Indicates the occupations of migrants at the time of migration.

[b] Includes once-abroad and still abroad migrants.

## Table 7—Distribution of landholdings among migrant and nonmigrant households, 1986/87

| Size of Landholding[a] | Percent of Individual Migrants[b] (N = 339) | Percent of Individual Nonmigrants (N = 661) |
|---|---|---|
| (feddans) | | |
| 0 | 60.5 | 56.4 |
| < 1 | 15.6 | 18.2 |
| 1 – < 2 | 14.7 | 12.9 |
| 2 – < 3 | 3.8 | 6.2 |
| 3 – < 5 | 3.8 | 3.8 |
| 5 – < 10 | 0.9 | 1.2 |
| ≥ 10 | 0.6 | 1.4 |
| Total | 100.0 | 100.0 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: 1 feddan = 1.038 acres. Numbers may not add to totals due to rounding.

[a] Landholdings include land rented and owned.

[b] Includes households with either once-abroad or still-abroad migrants.

percent). This small difference between households in the lowest (landless) category can be attributed to two important factors. First, as noted above, many rural Egyptian households do not need land to survive because they are employed outside of agriculture. Thus, many of the "landless" households in Table 7 are in fact employed in nonagricultural activities such as government work and private business. Second, landless agricultural households should no longer be viewed as the poorest in rural Egypt. In recent years the international migration of villagers—and especially the migration of agricultural laborers—has helped boost the wages of those belonging to the landless category. (See the Appendix for more discussion of this issue.)

## Economic Characteristics of Migrants: Estimating Predicted Income Functions

To pinpoint the economic status of international migrants, it would be easiest to analyze the actual income data collected on migrant and nonmigrant households. This appears to be the procedure followed by other analysts of migration in rural Egypt (Khafagi 1983; El-Dib, Ismael, and Gad 1984). However, this procedure cannot be followed here because 104 of the 339 migrant households still have a migrant working abroad. Thus, in attempting to determine income without remittances for all households, it is not known what the per capita incomes of these 104 households would have been had these migrants stayed home. It therefore becomes necessary to predict the per capita incomes of all migrant households, both once abroad and still abroad, excluding remittances. Then, to be consistent in the treatment of incomes, it is necessary to predict the per capita incomes of all households including remittances.

In pursuit of these ends, the following procedure is used. First, the parameters predicting per capita income per household excluding remittances (PREX) are estimated from the 661 households that have not sent a migrant abroad. These parameters are then applied to once-abroad and still-abroad migrant households in order to predict the incomes of these households without remittances.[10] The equation used is

$$\text{PREX} = \text{LND} + \text{EDUC} + \text{HS} + \text{PROMALE13}, \qquad (6)$$

where

LND = size of land farmed (rented and owned) by a household,
EDUC = mean education of male household members over 18 years of age (one if preparatory school or higher, zero otherwise),
HS = household size, and
PROMALE13 = males over 13 years as a proportion of household size.

In order to predict per capita incomes *with* remittances for the once-abroad and still-abroad migrant households, equation (6) is revised to include migration dummy variables. The dependent variable in the revised equation is per capita household income including remittances (PRIN). The revised equation can be written as

$$\text{PRIN} = \text{LND} + \text{EDUC} + \text{HS} + \text{PROMALE13} + \text{MIG1} + \text{MIG2}, \qquad (7)$$

where MIG1 is households with migrants who were once abroad and MIG2 is households with migrants who are still abroad. In equation (7), PRIN for nonmigrant households is calculated by setting MIG1 and MIG2 to zero.

In equations (6) and (7), the variable for household size (HS) captures the effect of family size on household income. This variable includes migrants when the equations are applied to once-abroad and still-abroad migrant households. In these equations, it is hypothesized that LND and EDUC are positively correlated with per capita household income, whereas PROMALE13 is entered in the equations to capture the effect of the number of males on household income. The two migration dummy variables—MIG1 and MIG2—capture the impact of migration on incomes when remittances are included.

Table 8 summarizes the parameter results obtained from using equation (6) to estimate predicted per capita household income excluding remittances. All of the coefficients in Table 8 are significantly different from zero at the 5 percent level.

Table 9 reports the results obtained when equation (7) is applied to all 1,000 households, excluding remittances. It is designed to check the parameter findings reported in Table 8, which are shown to be robust. The high $R^2$ (0.999) in Table 9 should be disregarded because the purpose of the equation is heuristic rather than predictive. All of the coefficients in Table 9 are in the same direction and of the same magnitude as those in the preceding table, and four of the six coefficients are significantly different from zero at the 5 percent level.

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[10] This method of predicting the incomes of the three sets of households assumes that the only way in which nonmigrant households differ from once-abroad and still-abroad migrant households is that migrant households had or still have a migrant. Nonmigrant and migrant households are not assumed to differ in any entrepreneurial or other sense that might affect their income in a manner apart from the relationships captured by the variables used in the predicted income equations.

### Table 8—Regression to estimate predicted per capita household income (excluding remittances)

| Variable | Regression Coefficient | t-Ratio |
|---|---|---|
| Land farmed (rented and owned) (LND) | 5.540 | 19.713** |
| Mean education of male household members over 18 years (EDUC) (one if preparatory school or higher, zero otherwise) | -7.076 | -3.283** |
| Household size (HS) | -2.355 | -9.124** |
| Males in household over 13 years as proportion of household size (PROMALE13) | 44.878 | 9.748** |
| Constant | 29.406 | 11.214** |
| $R^2 = 0.469$ | | |

Notes: Regression is based on 661 nonmigrant households. The parameters are used to estimate predicted per capita income (excluding remittances) for once-abroad and still-abroad migrant households. The dependent variable is per capita household income excluding remittances (PREX).

**Difference is significant at the .05 level.

Taken together, Tables 8 and 9 show that LND is strongly and positively correlated with predicted per capita household income. This is to be expected, given the importance of land in this and most other rural Third World areas. PROMALE13 is also strongly and positively correlated with predicted per capita household income, as is to be expected in an environment where only males are normally permitted to earn income outside of the household and where the presence of many non-wage earners (children, for example) may actually represent a burden on the household's overall economic position.

It may seem surprising that EDUC is strongly and negatively correlated with predicted per capita household income. This relationship does not mean that an educated

### Table 9—Regression to estimate predicted per capita income, excluding remittances, of all households surveyed

| Variable | Regression Coefficient | t-Ratio |
|---|---|---|
| Land farmed (rented and owned) (LND) | 5.524 | 914.594** |
| Mean education of male household members over 18 years (EDUC) (one if preparatory school or higher, zero otherwise) | -7.066 | -179.964** |
| Household size (HS) | -2.317 | -519.948** |
| Males in household over 13 years as proportion of household size (PROMALE13) | 44.869 | 529.709** |
| Migrant (once abroad) (MIG1) | -0.046 | -1.459 |
| Migrant (still abroad) (MIG2) | 0.011 | 0.258 |
| Constant | 29.202 | 619.814** |
| $R^2 = 0.999$ | | |

Notes: Regression includes all 1,000 households and uses migration dummy variables in order to check the consistency of the coefficients in Table 8. The dependent variable is per capita household income excluding remittances (PREX).

**Difference is significant at the .05 level.

farmer earns less than an uneducated farmer, but that educated people in rural Egypt do not usually become farmers; instead they seek government employment.[11] Not only must educated people wait years to receive a government job, but when they do begin working they start at very low wage rates—LE 30-60 (US$22-$44) per month in the countryside. All of this makes the returns to preparatory and secondary school education quite low in rural Egypt (see the Appendix for more discussion of this issue).

When equation (7) is used to estimate predicted per capita household income including remittances for once-abroad and still-abroad households, five of the six coefficients are significantly different from zero at the 5 percent level (Table 10). With only one exception, all of the coefficients in Table 10 are of the same magnitude as those in Table 9. The one exception, however, is notable. In Table 10, MIG2 is strongly and significantly correlated with predicted per capita household income including remittances, whereas in Table 9, this same variable is small and not statistically correlated with predicted per capita income excluding remittances. This dramatic switch is to be expected where remittances account for such a large share of per capita income for migrant households.

It is now possible to predict per capita household income both excluding and including remittances for nonmigrant, once-abroad, and still-abroad migrant households (Table 11). When remittances are excluded, nonmigrant households have the highest mean predicted per capita income—11.9 percent higher than that of once-abroad migrant households and 1.5 percent higher than that of still-abroad migrant households.

Although nonmigrant households have higher incomes than still-abroad migrant households had before migration, the incomes of the latter soar once a family member

## Table 10—Regression to estimate predicted per capita income, including remittances, of all households surveyed

| Variable | Regression Coefficient | t-Ratio |
|---|---|---|
| Land farmed (rented and owned) (LND) | 5.585 | 38.264** |
| Mean education of male household members over 18 years (EDUC) (one if preparatory school or higher, zero otherwise) | -5.601 | -5.903** |
| Household size (HS) | -2.955 | -27.436** |
| Males in household over 13 years as proportion of household size (PROMALE13) | 49.226 | 24.049** |
| Migrant (once abroad) (MIG1) | 0.051 | 0.452 |
| Migrant (still abroad) (MIG2) | 6.496 | 41.402** |
| Constant | 31.569 | 27.728** |
| $R^2 = 0.826$ | | |

Notes: Regression includes all 1,000 households. The parameters are used to estimate predicted per capita income (including remittances) for once-abroad and still-abroad migrant households. The dependent variable is per capita household income including remittances (PRIN).

**Difference is significant at the .05 level.

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[11] Since the late 1950s the Egyptian government has followed a policy of guaranteeing government employment to every high school and college graduate (Adams 1986, 45).

Table 11—Predicted per capita income per month of nonmigrant, once-abroad migrant, and still-abroad migrant households

| Household Group | Predicted Mean Income/Capita/Household/Month | |
|---|---|---|
| | Excluding Remittances | Including Remittances |
| | (LE) | |
| Nonmigrant (N = 661) | 33.31 | 33.31 |
| Once-abroad migrant (N = 235) | 29.76<br>(2.96)** | 29.76<br>(2.96)** |
| Still-abroad migrant (N = 104) | 32.81<br>(2.10)** | 76.75<br>(−16.78)** |

Notes: Numbers in parentheses are t-statistics (two-tailed), which measure differences between nonmigrant households and once-abroad or still-abroad households. Household income figures are predicted values and thus may not sum up to the actual figures recorded earlier. LE 1 = US$0.73.
**Differences between households are significant at the .05 level.

goes abroad. When remittances are included, the mean predicted per capita income of still-abroad migrant households is 130 percent higher than that of nonmigrant households.

## Specification and Estimation of the Migration Model

The balance of this chapter uses the preceding predicted income calculations to specify and estimate a model of the social and economic determinants of migration. To be useful, such a model should take into account the separate effects of three sets of variables—individual, household, and community or village-wide factors—on the decision to migrate. Omission of any one of these sets of variables could result in a misspecified model or biased estimates of the causal relationships of going to work abroad or both.[12]

The decision to migrate may be viewed as a process whereby an individual i in household j in village k considers information and weighs consequences at the individual, household, and village levels. The simplest form of such a model is

$$M_{ijk} = f(X_{ijk}, X_{jk}, X_k), \tag{8}$$

where

$M_{ijk}$ = probability of migration of the *ith* individual in the *jth* household in the *kth* community,

$X_{ijk}$ = individual-level variables,

$X_{jk}$ = household-level variables, and

$X_k$ = community or village-wide variables.

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[12] For a discussion of the importance of including village-level variables in estimated migration equations, see Bilsborrow (1981).

In this model the dependent variable (M) is dichotomous— migration (once-abroad or still abroad) or no migration. It can be hypothesized to be a function of the following independent measures.

### Individual-level Variables

Age (for migrants, measured at the time of migration) (AGE),
Marital status (one if married, zero otherwise) (MAR),
Employment (operationalized as a set of dummy variables explained below) (EMP), and
Education (operationalized as a set of dummy variables explained below) (EDUC).

### Household-level Variables

Land farmed (rented and owned) by household (LND),
Males in household over 13 years of age (MALE13),
Age of household head (AGEHH), and
Predicted per capita household income excluding remittances (PREX).

### Village-level Variables

Percent of agriculturalists (farmers/peasants, agricultural laborers) in village owning or renting less than 0.5 feddan (AGR), and
Distance (in kilometers) of the village from the main road to Cairo (DIS).

It may be useful to explain several of these independent variables in relation to the outcomes hypothesized by migration and human capital models of development.

For employment, dummy variables are created to capture the effect of employment on migration. For both once-abroad and still-abroad migrant households, these dummy variables are measured at the time of migration. EMP1 takes a value of 1 if the male is an agricultural laborer and zero otherwise. EMP2 takes a value of 1 if the male is a government worker and zero otherwise. Since agricultural laborers are uneducated and government employees are usually high-school educated, it is expected from the human capital model that the EMP1 coefficient will be negative and the EMP2 coefficient positive.

Dummy variables are also created to capture the effect of education on migration. EDUC1 takes a value of 1 if the male has no education (is illiterate) and zero otherwise. EDUC2 takes a value of 1 if the male has completed more than an elementary school education and zero otherwise. Once again, because migration theory generally predicts the migration of the more educated, EDUC1 is expected to have a negative coefficient and EDUC2 a positive coefficient.

It is difficult to predict a priori the effect of land on migration. Land is positively correlated with income in most rural Third World areas, and it has frequently been observed that higher-income people have a greater propensity to migrate (Stahl 1982; Connell et al. 1976). However, landownership entails responsibilities, which well may inhibit migration among landowners (Shaw 1974). By the same token, landlessness implies fewer ties to community; therefore landless people—especially landless agricultural workers—may be more likely to migrate (El-Dib, Ismael, and Gad 1984; Morrison 1980).

The variable MALE13 refers to the number of males aged 13 and above in the household. According to migration literature, large families or families with more males have a higher propensity to produce migrants (Roberts 1982; Moock 1973). Because females in rural Egypt do not normally work outside of the home, more males are needed to take over the work of the migrant member. It is therefore hypothesized that the MALE13 coefficient will be positive.

The variable AGEHH refers to the age of the household head. For both once-abroad and still-abroad migrant households, this variable is measured at the time of migration. Some analysts (Lipton 1980; Connell et al. 1976) believe that migration is in part a life-cycle phenomenon in which families with males in their early twenties are more likely to participate. These studies suggest that families with older household heads should have a higher propensity to produce migrants. It is therefore hypothesized that the AGEHH coefficient will be positive.

Like land, the impact of income upon migration is difficult to predict. Some studies have found a positive correlation between family income and migration (Lipton 1980; Nelson 1976), while others have found just the opposite (El-Dib, Ismael, and Gad 1984; Wilkie 1971). It should, however, be noted that the findings of many of these earlier studies are weakened by their reluctance to use predicted income functions in order to accurately establish family income *before* migration. In this study, predicted per capita income excluding remittances (PREX) for each household is calculated from equation (6).

AGR measures the percentage of agriculturalists (farmers/peasants and agricultural laborers) in the village owning or renting less than 0.5 feddan. According to the migration literature, areas with a high incidence of landless or near-landless agricul-turalists may produce more migrants (Lipton 1980; Shaw 1974). It is thus hypothesized that the AGR coefficient will be positive.

DIS attempts to capture the relationship between proximity to the main road to Cairo and migration. According to most studies, distance from roads and major urban areas typically reduces the propensity to migrate (Bilsborrow et al. 1987; Thomas and Croner 1975; Ravenstein 1885). It is therefore hypothesized that the DIS variable will be negative.

## Empirical Results of the Model

Equation (8) is run for all 1,859 males over 18 years of age in the sample using a logit regression. A stepwise procedure is needed because the variable PREX is a predicted value that is estimated from three other variables in the equation: EDUC, LND, and MALE13. For this reason, equation (8) is run in four steps, with each step including a different variable. The final, fifth step includes all of the specified variables.

In steps 1, 2, and 4 of the regression, 5 of the 12 variables are significantly different from zero at the 10 percent level (Table 12). For the full regression, 6 of the 12 variables are significant at this level of confidence.

Beginning with the individual-level variables—AGE, MAR, EMP, and EDUC—many of the signs are consistent with standard economic theories of human capital and migration. The variable AGE is, as expected, negative and significant because younger males enjoy greater returns to migration and lower relocation costs.[13]

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[13] Estimating migration equation (8) with an age and an age squared variable produces the expected relationship: both variables are significant, with the age variable being positive and the age squared variable being negative.

## Table 12—Logit regression analysis of international migration for all males surveyed

| Variable | Stepwise Equations | | | | Full Equation |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Age of male (AGE)$^a$ | -0.050<br>(-7.580)** | -0.052<br>(-8.032)** | -0.051<br>(-7.836)** | -0.051<br>(-7.795)** | -0.050<br>(-7.546)** |
| Marital status of male (MAR) (one if married, zero otherwise) | 1.431<br>(7.851)** | 1.360<br>(7.916)** | 1.348<br>(7.803)** | 1.298<br>(7.451)** | 1.474<br>(7.669)** |
| Employment status of male (EMP1) (one if agricultural laborer, zero otherwise) | 1.227<br>(5.877)** | 1.127<br>(5.357)** | 1.207<br>(5.769)** | 1.209<br>(5.790)** | 1.141<br>(5.401)** |
| Employment status of male (EMP2) (one if government worker, zero otherwise) | 0.005<br>(0.025) | 0.078<br>(0.465) | 0.084<br>(0.509) | 0.066<br>(0.397) | -0.017<br>(-0.088) |
| Age of household head (AGEHH)$^a$ | -0.026<br>(-5.503)** | -0.024<br>(-5.051)** | -0.025<br>(-4.657)** | -0.026<br>(-5.426)** | -0.025<br>(-4.693)** |
| Educational status of male (EDUC1) (one if no education, zero otherwise) | 0.156<br>(0.873) | . . . | . . . | . . . | 0.137<br>(0.765) |
| Educational status of male (EDUC2) (one if more than elementary school, zero otherwise) | 0.361<br>(1.678)* | . . . | . . . | . . . | 0.385<br>(1.779)* |
| Land farmed (rented and owned) (LND) | . . . | -0.107<br>(-2.675)** | . . . | . . . | -0.119<br>(-2.482)** |
| Number of males over 13 years in household (MALE13) | . . . | . . . | -0.104<br>(-0.213) | . . . | 0.023<br>(0.457) |
| Predicted per capita household income (excluding remittances) (PREX)$^b$ | . . . | . . . | . . . | -0.007<br>(-1.684)* | 0.001<br>(0.291) |
| Percent of agriculturalists in village farming less than 0.5 feddan (AGR)$^c$ | -0.001<br>(-0.222) | -0.003<br>(-0.517) | -0.002<br>(-0.284) | -0.002<br>(-0.328) | -0.003<br>(-0.430) |
| Distance of village from main road to Cairo (DIS) | -0.001<br>(-0.088) | -0.002<br>(-0.261) | -0.002<br>(-0.238) | -0.001<br>(-0.149) | -0.001<br>(-0.046) |
| Constant | 0.230<br>(0.447) | 0.686<br>(1.399) | 0.537<br>(1.089) | 0.790<br>(1.545) | 0.288<br>(0.513) |

Notes: Includes 1,859 males over 18 years of age. Numbers in parentheses are t-statistics (two-tailed). The dependent variable in the regression is migration (M). 1 feddan = 1.038 acres.

[a] For once-abroad and still-abroad migrants, ages of males (AGE) and ages of households heads (AGEHH) are measured at the time of migration.

[b] Predicted per capita household income (excluding remittances) is calculated from equation (6).

[c] The term agriculturalists includes all those employed as either farmer/peasants or agricultural laborers.

*Difference is significant at the .10 level.

**Difference is significant at the .05 level.

Although migration theory has little to say about the effects of marriage on migration, it is interesting to note that the variable MAR (marital status) is positive and significant; that is, marriage tends to encourage migration. This finding may reflect the relatively high mean age (31.3 years at time of migration) of migrants in the sample. In the Egyptian countryside, males—especially uneducated males working in agriculture—tend to marry in their early to mid-twenties.

The results for the EMP1 and EMP2 variables are not consistent with expectations from migration theory. Both of these variables are contrary to predicted outcomes: the EMP2 variable (government worker) is not statistically significant, while the EMP1 variable (agricultural laborer) is significant and positive, rather than negative. Since most agricultural laborers are illiterate, the latter outcome suggests that less education is associated with more migration. A partial explanation for this paradoxical outcome may be that in the sample 80 percent of agricultural laborers belong to a landless household; in other words landlessness combined with primary employment in agriculture may push people abroad. This explanation, however, implies that landlessness and employment are more important determinants of migration than education. This point will be investigated later.

The results for the EDUC1 and EDUC2 variables also tend to vary from expected outcomes. The variable EDUC2 (more than elementary education) is positive and significant as expected, but EDUC1 (no education) has neither the right sign nor significance. Although statistically insignificant, the outcome for the EDUC1 variable tends to reinforce the idea that education may not necessarily have the simple positive effect on migration that is predicted by migration and human capital theory. This finding parallels that of Bilsborrow et al. (1987: 201), who found that in rural Ecuador, "it is the less educated who migrate more, because they have to."[14] More research is needed to delineate the exact character of the relationship between education and migration.

Turning now to the household-level variables (LND, AGEHH, MALE13, and PREX), the effect of LND on migration is negative and significant according to regression (2) of Table 12. Evidently, the responsibilities of renting or owning land tend to keep men at home. But the variable AGEHH has a negative and significant effect on migration. This unexpected outcome suggests that migration is *not* a life-cycle phenomenon. According to the data, males from families with older heads—and potentially more "age-eligible" migrants—are less likely to migrate abroad.

Regression (3) in Table 12 shows that the number of males over age 13 in the household (MALE13) has a negative effect on migration. Although it is not statistically significant, this is a surprising finding, since the migration literature generally suggests a positive relationship between number of household males and propensity to migrate. Part of the inconsistency here may be caused by the method of data aggregation. The unit of analysis for these regression equations is the individual male. However, when the unit of analysis becomes the individual *household*, the results tend to support a positive relationship between number of males and propensity to migrate. Whereas 27.0 percent of the households with fewer than two males over age 13 have a migrant, fully 56.9 percent of the households with five or more males have a migrant.

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[14] According to Bilsborrow et. al (1987, 201), in rural Ecuador "migration propensity peaks at the primary-certificate level for males, with further education associated with lower migration."

Of special interest to this study is the effect of the income variable (PREX) on migration. According to regression (4) in Table 12, this variable is negative and significant. These results suggest that, for the entire set of males over 18 years, males from higher-income households (remittances excluded) are *less* likely to migrate abroad.[15]

Neither of the village-level variables (AGR or DIS) have a statistically significant effect on migration.[16] Such results are unexpected inasmuch as migration studies in other developing countries (Bilsborrow et al. 1987; Brown and Goetz 1987; Connell et al. 1976) have found these variables to have a significant influence on migration. Perhaps the lack of statistical significance here lies in the nature of the data set. The data in this study are drawn from three neighboring villages. Among these three communities, rates of migration abroad are surprisingly uniform, varying from a high of 20.6 percent of all males over 18 years in one village to a low of 18.7 percent. The lack of variation in levels of migration between villages, coupled with the close proximity of these communities to one another within a similar agricultural area, means that neither of the village-level variables had a significant influence on migration.

Table 13 extends and refines the logit results reported in Table 12 by presenting a list of predicted probabilities for international migration. These probabilities are calculated from regression (4), since this is the equation containing the predicted income variable (PREX). When all variables are at the mean, any male in the sample of 1,859 males has an 18.7 percent probability of going to work abroad. Yet when the values of different variables vary from the mean, the probability of international migration also changes. For instance, a male from a household with a relatively low predicted per capita monthly income (excluding remittances)—LE 20 (US$15)—has a 20.6 percent probability of migrating, whereas a male from a household with a much higher predicted per capita monthly income—LE 35 (US$26)—has a probability of only 18.5 percent. These figures serve to emphasize the point that the per capita income status of the household before migration is not the most important factor causing males to migrate. Rather employment status in agriculture combined with lack of land is the leading factor. Row (1) of Table 13 shows that agricultural laborers have the highest probability of migration: 57.7 percent. In their case, poverty of land combines with employment in agriculture to "push" people abroad.

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[15] It should be emphasized that these findings pertain only to the whole set of males over 18 years old. As will be shown below, when migrants are divided into their once-abroad and still-abroad categories, the still-abroad category of migrants is dominated by males from higher-income households, excluding remittances (see Table 16).

[16] Estimating equation (8) without the village-level variables (AGR and DIS) produces no change in either the signs or the significances of any of the remaining independent variables.

## Table 13—Predicted probabilities of international migration for all males, using logit results

| Probability Situation | Predicted Probability of Migration Abroad[a] |
|---|---|
| | (percent) |
| All independent variables at the mean, *except*<br>Employment status is agricultural laborer (EMPI = 1) | 57.7 |
| All independent variables at the mean, *except*<br>Age of male is 25 years (AGE = 25) | 33.3 |
| All independent variables at the mean, *except*<br>Male is married (MAR = 1) | 27.5 |
| All independent variables at the mean *except*<br>Predicted per capita household income per month (excluding remittances) is LE 20 (PREX = 20) | 20.6 |
| All independent variables at the mean (no exceptions) | 18.7 |
| All independent variables at the mean, *except*<br>Predicted per capita household income per month (excluding remittances) is LE 35 (PREX = 35) | 18.5 |
| All independent variables at the mean, *except*<br>Employment status is *not* agricultural laborer (EMP = 0) | 17.2 |
| All independent variables at the mean, *except*<br>Age of male is 40 years (AGE = 40) | 15.5 |
| All independent variables at the mean, *except*<br>Male is *not* married (MAR = 0) | 7.5 |

Notes: Includes 1,859 males over 18 years of age. LE 1 = US$0.73.

[a] Predicted probability of migration (PR) is calculated from regression (4) in Table 12 using the equation

$$PR = (e^{\beta x})/(1 + e^{\beta x}),$$

where $\beta$ = coefficient of logit regression and x = the value of the independent variable.

# 4

# INTERNATIONAL REMITTANCES AND INCOME INEQUALITY

Even when international remittances are quite large, there is no agreement in the literature regarding the effects of these resource transfers on income distribution. Gilani, Khan, and Iqbal (1981, Part 1: 41) in their study of international remittances of Pakistani migrants argue that, on the whole, remittances "worsened income distribution in the country." According to these authors, international remittances had a negative impact on income distribution because they were earned mainly by upper-income villagers. Other studies, however, suggest a very different outcome. For example, in their study of two Mexican villages, Stark, Taylor, and Yitzhaki (1986) found that internal and international remittances had an egalitarian effect on village income distribution.[17]

To shed additional light on this debate, the results of the migration and predicted income functions reported in Chapter 3 are used in this chapter to analyze the effects of international remittances on rural income distribution. This analysis focuses on the static, first-order effects of remittances on income distribution, evaluating the change that occurs in income inequality when remittances are included, compared with the situation when they are excluded. In this analysis the remittances earned by the 104 households that still have a migrant abroad are included. However, because of the difficulty of determining at what point in time the 235 households with once-abroad migrants received their remittances, the overseas earnings of these migrants are *not* included in the calculations.

## Remittances, Earnings, and the Propensity to Remit

At the outset it is necessary to address two questions remaining from the previous chapter. First, how much do different income classes of migrants earn abroad? And second, what is the propensity of different income groups to remit?

The first of these questions is addressed by analyzing both the pattern of income earned abroad and the length of time abroad (Table 14). Both mean monthly income abroad and months spent abroad are distributed fairly evenly among the various quintiles. For example, the actual (as opposed to the predicted) mean monthly income abroad for the bottom two income quintiles is higher than that recorded for the top quintile. Similarly, the mean number of months spent abroad is highest for still-abroad migrants from the second lowest quintile. On the whole, there seems to be no real difference between migrants from low-income households and those from high-income households either in earnings or time spent abroad. This conclusion is underscored by the

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[17] For international remittances alone, Stark, Taylor, and Yitzhaki (1986) found that remittances from abroad had an equalizing influence on incomes in one village and an unequalizing influence in another.

Table 14—Actual income earned and months spent abroad by still-abroad migrants, ranked by predicted per capita household income, excluding remittances, 1986/87

| Rank[a] | Number of Still-Abroad Migrants in Group | Actual Mean Monthly Income Earned Abroad | Mean Number of Months Spent Abroad | Total Actual Mean Income Earned Abroad[b] |
|---|---|---|---|---|
| (percentile) | | (LE) | | (LE) |
| Lowest 20 | 25 | 372.60<br>(153.02) | 20.3<br>(7.7) | 7,563.78 |
| Second 20 | 17 | 370.59<br>(145.84) | 23.6<br>(12.5) | 8,745.92 |
| Third 20 | 15 | 390.67<br>(139.72) | 23.2<br>(11.3) | 9,063.54 |
| Fourth 20 | 27 | 353.70<br>(81.95) | 18.4<br>(9.1) | 6,508.08 |
| Highest 20 | 34 | 367.65<br>(86.94) | 22.2<br>(10.3) | 8,161.83 |
| Highest 10[c] | 17 | 385.29<br>(96.44) | 22.2<br>(10.0) | 8,553.43 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: The numbers in parentheses are standard deviations of mean. LE 1 = US$0.73.

[a] The 1,000 households surveyed are ranked in percentiles by predicted per capita income excluding remittances.

[b] Total actual mean income earned abroad is derived by multiplying the monthly income by the number of months spent abroad.

[c] The top 10 percent are included in the numbers for the top 20 percent.

data in the last column, which show that still-abroad migrants from the lower-middle groups—the second and third income quintiles—earned the highest total actual mean incomes abroad.

The propensity to remit income earned abroad also does not vary much by quintile (Table 15). The data show that still-abroad migrants from the middle group—the third income quintile—have the highest mean propensity to remit. Still-abroad migrants from the top income quintile have only a slightly higher mean propensity to remit than migrants from the bottom two quintiles.

The results shown in Table 15 differ from those studies that suggest that the propensity to remit varies positively with income level (International Labour Organisation [1987] cited in Kazi 1989; Gilani, Khan, and Iqbal 1981). However, because of methodological problems, it is not clear whether these earlier studies were measuring propensity to remit on the basis of income excluding remittances, income including remittances, or even migrant income earned abroad.[18] Moreover, other studies have

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[18] Neither the International Labour Organisation (1987) survey cited in Kazi (1989, Table 6, 16) nor the Gilani, Khan, and Iqbal (1981) study use predicted income functions to establish incomes excluding remittances for migrant households. Moreover, the International Labour Organisation study calculates propensities to remit on the basis of "income category abroad."

## Table 15—Propensity to remit income for still-abroad migrants, ranked by predicted per capita household income, excluding remittances

| Rank[a] | Number of Still-Abroad Migrants in Group | Mean Propensity to Remit Income Earned Abroad[b] | Standard Deviation |
|---|---|---|---|
| (percentile) | | (percent) | |
| Lowest 20 | 25 | 0.62 | 0.14 |
| Second 20 | 17 | 0.63 | 0.13 |
| Third 20 | 15 | 0.66 | 0.11 |
| Fourth 20 | 27 | 0.62 | 0.12 |
| Highest 20 | 34 | 0.65 | 0.09 |
| Highest 10 | 17 | 0.66 | 0.09 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

[a] The 1,000 households surveyed are ranked in percentiles by predicted per capita income excluding remittances.

[b] Propensity to remit income for each migrant is defined as

Propensity to remit = Remittances/Total income abroad.
Total income abroad = (Months abroad) (Monthly income abroad).
Remittances = Total income abroad – Travel costs – Housing costs abroad – Food costs abroad.

found that, although the absolute amount of transfers sent home by rural migrants increases with income, "transfers sent as a proportion of income decline" (Knowles and Anker 1981, 211). On the basis of these studies, the average propensities to remit recorded in Table 15 should be considered reliable, especially since they are of the same general magnitude as those estimated for Egyptian international migrants by Egypt's National Specialized Councils (1983)—56 percent. This figure includes both remittances and "real savings" of Egyptians abroad.

The findings in Tables 14 and 15 are important because they show *no* major variations by income class among still-abroad migrants in income earned abroad, time spent abroad, or propensity to remit. Multiplying the results of column (4) of Table 14 by column (2) in Table 15 shows that the second and third quintiles actually remitted the most money (LE 5,509 and LE 5,982) whereas the highest income group remitted only LE 5,305.

## Remittances and the Number of Migrants

In order to see whether lower-middle-income groups produce as many migrants as those from higher-income groups, Table 16 presents the distribution of once-abroad and still-abroad migrants through the income order. The total number of migrants abroad was drawn fairly evenly from all income groups [column (1)]. In fact, the lowest quintile actually produced one of the highest shares of total migrants. But the distribution of migrants changed considerably between the once-abroad and still-abroad categories. The shares of the two lower-middle income groups—the second and third income quintiles—are much smaller in the still-abroad category. At the same time, the fourth and the highest quintiles increased their shares of migrants by 47 and 147 percent, respectively, between the once-abroad and still-abroad categories. Column (3) shows that the highest income quintile has the largest share of migrants in the still-abroad category.

Table 16—Distribution of individual imigrants among income quintiles ranked by predicted per capita household income, excluding remittances

| Rank[a] | Percent of All 363 Individual Migrants in Group (1) | Percent of 244 Once-Abroad Migrants in Group (2) | Percent of 119 Still-Abroad Migrants in Group (3) | Percent of Change Between Columns (2) and (3) (4) |
|---|---|---|---|---|
| (percentile) | | | | |
| Lowest 20 | 22.87 | 23.77 | 21.01 | -11.61 |
| Second 20 | 18.46 | 20.49 | 14.29 | -30.26 |
| Third 20 | 22.87 | 27.87 | 12.61 | -54.75 |
| Fourth 20 | 18.46 | 15.98 | 23.54 | 47.25 |
| Highest 20 | 17.36 | 11.89 | 29.41 | 147.35 |
| Highest 10 | 9.09 | 6.56 | 14.26 | 117.38 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

[a] The 1,000 households surveyed are ranked in percentiles by predicted per capita income excluding remittances.

## Remittances and Income Inequality

The disproportionate share of still-abroad migrants produced by the upper-income groups may have a negative effect on income distribution. To evaluate this effect, it is necessary to compare the first-order changes that occur in income distribution when remittances are excluded with those that occur when remittances are included. As noted above, the latter situation includes the remittances of those 104 households that still have a migrant abroad.

In Table 17, when remittances are included, households from the lower-middle-income quintiles benefit less than households in other quintiles. The share of total predicted per capita income going to households in the second income quintile declines by 9.6 percent in column (3), when remittances are included, while in column (6) the predicted mean income of households in this group increases by only 3.2 percent. In contrast, the percentage of total predicted per capita income going to households in the highest income quintile increases by 16.0 percent and the predicted mean income of these households rises by 32.4 percent. When remittances are included, the largest percentage increases in both relative and mean income are recorded for the highest quintile.

Table 17 also shows that the distribution of rural household income worsens when remittances are included. The Gini coefficient of inequality increases from 0.233 to 0.290 with remittances. Theil's entropy measure also rises, climbing from 0.105 to 0.138. Both of these measures of inequality suggest a rather sharp increase in rural inequality when remittances from abroad are included in per capita household income.[19]

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[19] It should be noted that the use of predicted income figures to calculate these changes in inequality may have the effect of *underestimating* the actual degree of increase in income inequality. Depending on the percentage of variance explained by the predicted equations, the predicted income figures will have a smaller variance than actual incomes. This may cause estimates of changes in the degree of inequality to be smaller than they actually were.

## Table 17—Effects of international remittances on rural per capita household income distribution, 1986/87

| Rank[a] | Percent of Predicted per Capita Income | | Percent of Change Between Columns (1) and (2) (3) | Mean Predicted per Capita Income per Month | | Percent of Change Between Columns (4) and (5) (6) |
|---|---|---|---|---|---|---|
| | Excluding Remittances (1) | Including Remittances (2) | | Excluding Remittances (4) | Including Remittances (5) | |
| (percentile) | | | | (LE) | | |
| Lowest 20 | 9.80 | 8.96 | −8.63 | 15.89 | 16.57 | 4.24 |
| Second 20 | 15.31 | 13.84 | −9.56 | 24.81 | 25.60 | 3.18 |
| Third 20 | 18.78 | 17.18 | −8.50 | 30.45 | 31.78 | 4.39 |
| Fourth 20 | 23.03 | 21.64 | −6.02 | 37.33 | 40.03 | 7.22 |
| Highest 20 | 33.08 | 38.38 | 16.01 | 53.63 | 70.99 | 32.36 |
| Highest 10 | 38.20 | 49.67 | 30.00 | 61.94 | 91.86 | 48.32 |
| Gini coefficient[b] | 0.233 | 0.290 | 24.46 | ... | ... | ... |
| Theil's entropy measure[c] | 0.105 | 0.138 | ..20 | ... | ... | ... |

Note: LE 1 = US$0.73.

[a] The 1,000 households surveyed are ranked in percentiles by predicted per capita income excluding remittances.

[b] The Gini coefficient is an index commonly used to measure the inequality of a distribution of income. It can be represented as

$$G = 1 + \frac{1}{H} - \frac{2}{HY} \sum_{1}^{H} p(h)\, y^h,$$

where

$H$ = number of units,
$y^h$ = quantity over which inequality is measured,
$Y$ = total inequality, and
$p(h)$ = rank assigned to household h ranked by y.

[c] Theil's entropy measure is another index used to measure inequality of distribution of income. Scaled to lie between 0 and 1, it can be expressed as

$$T = 1 - \frac{Y}{H} \exp\left(-\sum \frac{y^h}{Y} \operatorname{Ln} y^h\right).$$

Households in the lower-middle income quintiles—the second and third income groups—had far fewer migrants abroad at the time of the survey than those in the two highest income quintiles. The top quintiles—the fourth and fifth income groups—now had the largest share of migrants abroad. More than any other factor, it is the disproportionate number of still-abroad migrants belonging to the upper-income groups that serves to explain the sharp rise in rural inequality that occurs when remittances from abroad are included in per capita income.

It should, however, be noted that this negative effect is neither automatic nor inevitable. The data clearly show that at the time of the survey remittances had a negative effect on income distribution because upper-income groups had many more migrants abroad. Yet, in the once-abroad category of migrants, the lower-income groups sent virtually the same number of migrants abroad as households in the upper-income groups. If the number of migrants abroad had continued to be as evenly distributed, it may be logically inferred that remittances would also have had a more equitable effect on rural income distribution.

## Remittances and the Sources of Income Inequality

Another way to examine the impact of international remittances on rural inequality is to measure the contribution of remittances to overall income inequality. This can be done by determining what proportions of overall income inequality can be attributed to the various sources of income: agricultural income, nonagricultural income, and international remittances. Such an exercise can help answer the question, What is the role of remittances in determining overall income inequality?

Shorrocks (1982) has shown that the results of decomposing any inequality index depend on the rule used in the decomposition procedure.[20] For this reason, it seems best to base the decomposition analysis on two inequality indices—the coefficient of variation and the Gini coefficient—rather than on a single measure, in order to check the robustness of the results.

The inequality decomposition based on the coefficient of variation can be developed following Shorrocks (1982) and Ercelawn (1984). Let total income, y, consist of income from k sources. The variance of total income, $\sigma^2$, can be written as the sum of variances of each source of income, $\sigma_i^2$, and of the covariances between sources of income, $\sigma_{ij}$:

$$\sigma^2 = \Sigma\sigma_i^2 + \Sigma_{i\neq j}\sigma_{ij}. \qquad (9)$$

The contribution of the *ith* source of income to total income variance consists of the *ith* income variance and the part of the covariances allocated to the *ith* source. This leads to the expression:

$$\sigma^2 = \Sigma\sigma_{iy}, \qquad (10)$$

where the (absolute) contribution of the *ith* source is measured by its covariance with total income. This relationship can be rewritten to express the contribution in relative terms. The relative contributions remain the same whether inequality is measured by the variance or by the coefficient of variation; because the coefficient of variation places more emphasis on relative (rather than absolute) inequality, however, this measure will be adopted here. The decomposition equation corresponding to the coefficient of variation can be expressed as

$$\Sigma w_i c_i = 1;\ w_i = (\mu_i/\mu);\ c_i = \rho_i\ (\sigma_i/\mu_i)/(\sigma/\mu), \qquad (11)$$

where $w_i c_i$ is the so-called factor inequality weight of the *ith* source in overall inequality; $\mu_i$ and $\mu$ are the mean income from the *ith* source and from all sources, respectively; $c_i$ is the relative concentration coefficient of the *ith* source in overall inequality; and $\rho_i$ is the correlation coefficient between the *ith* income source and total income.

Turning to the inequality decomposition of the Gini coefficient, Pyatt, Chen, and Fei (1980) have shown that the Gini coefficient of total income, G, can be written as

$$G = (2/n\mu)\ \mathrm{Cov}(y,r), \qquad (12)$$

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[20] According to Shorrocks (1982, 199-200), in the absence of any restrictions, for any inequality measure, the inequality of total income can be allocated in many ways between the components of total income.

where n is the number of observations, y refers to the series of total incomes, and r refers to the set of corresponding ranks. On this basis the Gini coefficient of the *ith* source of income, $G_i$, can be expressed as

$$G_i = (2/n\mu)\,\mathrm{Cov}(y_i, r_i), \tag{13}$$

where $y_i$ and $r_i$ refer to the series of incomes from the *ith* source and corresponding ranks, respectively. Since total income is the sum of sources of income, the covariance between total income and its rank can be written as the sum of covariances between each income source and the rank of total income. Equations (12) and (13) can then be used to express the total income Gini as a function of the source Ginis:

$$G = \Sigma[(\mu_i/\mu)R_iG_i], \tag{14}$$

where R is the "correlation ratio" expressed as

$$R_i = \frac{\mathrm{cov}(y_i, r)}{\mathrm{cov}(y_i, r_i)} = \frac{\text{covariance between income source amount and total income rank}}{\text{covariance between income source amount and income source rank}}. \tag{15}$$

The decomposition equation corresponding to the Gini coefficient can then be expressed as

$$\Sigma w_i g_i = 1;\ w_i = (\mu_i/\mu);\ \text{and}\ g_i = R_i\,(G_i/G), \tag{16}$$

where $w_i g_i$ is the factor inequality weight of the *ith* source in overall inequality and $g_i$ is the relative concentration coefficient of the *ith* source in overall inequality.

Decomposing the coefficient of variation and the Gini coefficient provides two ways of measuring the contribution of international remittances to overall income inequality. First, it helps determine whether inequality in remittance income serves to increase or decrease overall income inequality. Second, it helps identify how much of the overall income inequality is due to remittance income.

An income source (such as remittances) can be defined as increasing or decreasing inequality on the basis of whether a larger share of that income source leads to an increase or decrease in overall income inequality. From the decomposition equations, it follows that the *ith* income source either increases or decreases inequality, depending on whether the relative concentration coefficient ($c_i$ or $g_i$) is greater or less than unity.[21] The results are reported in Table 18. In this table, all of the income figures are based on the predicted per capita household incomes including remittances calculated above.[22]

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[21] This analysis ignores feedback effects, that is, the effects that a change in the share of any source of income might have on distribution within that income source. Of course, such an assumption might be quite unrealistic for large changes in the share of any income source.

[22] Predicted per capita incomes (including remittances) for each source of income—agricultural, nonagricultural, and international remittances—are calculated on the basis of the proportion of actual gross income (including remittances) recorded for each source of income.

## Table 18—Decomposition of inequality: Relative concentration coefficients of sources of income in overall inequality

| Source of Income | Coefficient of Variation[a] | Gini Coefficient[b] |
|---|---|---|
| Agricultural | 0.721 | 1.097 |
| Nonagricultural | 0.906 | 0.374 |
| Remittances | 3.621 | 2.954 |

Note: All estimates are based on predicted per capita household income including remittances.

[a] The equation for concentration of the coefficient of variation is

$$c_i = \rho_i (\sigma_i / \mu_i)/(\sigma/\mu).$$

[b] The equation for concentration of the Gini coefficient is $g_i = R_i (G_i / G)$.

For agricultural income, the alternative decompositions give contradictory results.[23] Decomposition of the coefficient of variation reveals that agricultural income represents an inequality-decreasing source of income, whereas decomposition of the Gini coefficient suggests just the opposite. However, the two decompositions agree that international remittances increase income inequality. This finding is quite consistent with the results recorded in Table 17. As will be shown, remittances increase inequality because there is a high degree of inequality within remittance income, as well as a high degree of correlation between remittance and total income.

The relative factor inequality weights, which measure the contribution of a particular income source to overall inequality, are presented in Table 19. Shorrocks (1983) has shown how widely such factor inequality weights can vary depending on the index used to measure overall income inequality, and this is borne out by the results. In the decomposition of the coefficient of variation, remittance income has the smallest factor inequality weight and makes the smallest contribution to overall income inequality. In the Gini decomposition, however, remittance income takes second place in terms of its contribution to overall inequality.[24] In both decompositions, agricultural income makes the largest contribution to overall inequality. Depending on the decomposition measure, agricultural income accounts for between 43.0 and 65.5 percent of overall income inequality.

These results can be explained by analyzing the three elements of the Gini decomposition procedure: (1) the weight of the income source; (2) the source Gini; and (3) the correlation ratio between the income source and total income inequality (Table 20).

The first row of Table 20 reveals that agricultural income is the most important income source by far, accounting for 57.7 percent of all income. In contrast, remittance income accounts for only 9.6 percent of total income. Row (2) of the table, however, shows that remittance income has the highest source Gini and is thus the least evenly

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[23] As Ercelawn (1984, 7) has shown, this contradiction occurs either when $c_i < 1$ and $g_i \geq 1$ or when $c_i \geq 1$ and $g_i < 1$. The contradiction seems to reflect the greater sensitivity of the Gini coefficient to middle-income groups and of the coefficient of variation to extreme incomes.

[24] According to Ercelawn (1984, 9), such contradictory results occur because either $(g_j/g_i)<1$ and $(c_j/c_i)>1$ or $(g_j/g_i)>1$ and $(c_j/c_i)<1$.

## Table 19—Decomposition of inequality: Factor inequality weights of sources of income in overall inequality

| Source of Income | Coefficient of Variation[a] | Gini Coefficient[b] |
|---|---|---|
| Agricultural | 0.430 | 0.655 |
| Nonagricultural | 0.295 | 0.122 |
| Remittances | 0.275 | 0.224 |
| Total | 1.000 | 1.000 |

Note: All estimates are based on predicted per capita household income, including remittances.

[a] The factor inequality weight for the coefficient of variation is $w_i c_i$, where $w_i = \mu_i / \mu$, $c = \rho_i (\sigma_i / \mu_i) / (\sigma / \mu)$.

[b] The factor inequality weight for the Gini coefficient is $w_i g_i$, where $w_i = \mu_i / \mu$, $g_i = R_i (G_i / G)$.

distributed income source. This is because only 104 of 1,000 households receive international remittances. Row (3) reports the correlation ratios between income source and total income inequality. The figures show that inequality in remittance income is highly correlated with overall income inequality.

The data in Table 20 serve to explain the factor inequality weights reported in the preceding table. Agricultural income, for example, has the largest factor inequality weight and makes the largest contribution to overall inequality because it has a large share of total income and a middle-sized source Gini, and it is moderately correlated with overall income inequality. In contrast, remittance income makes only a small contribution to overall inequality. While remittance income has a large source Gini and is strongly correlated with overall income inequality, it has only a very small share of total income.

## Table 20—Decomposition of overall income inequality using a Gini coefficient

| Item | Agricultural Income | Nonagricultural Income | Remittance Income | Total |
|---|---|---|---|---|
| Source income weight[a] | 0.577 | 0.326 | 0.096 | 1.00 |
| Source Gini[b] | 0.509 | 0.675 | 0.932 | . . . |
| Correlation ratio between source and total inequality[c] | 0.626 | 0.161 | 0.924 | . . . |

Notes: All estimates are based on predicted per capita household income, including remittances.

[a] Source income weight $= w_i$.

[b] Source Gini, $G_i = 2 / n\mu_i \operatorname{cov}(y_i, r_i)$.

[c] Correlation ratio between source and total inequality,

$R_i = \operatorname{cov}(y_i, r) / \operatorname{cov}(y_i, r_i) =$ covariance between source income amount and total income rank / covariance between source income amount and source income rank.

# 5

# INTERNATIONAL MIGRATION, REMITTANCES, AND THE POOR

In the ongoing debate among policy researchers concerning the impact of international remittances on the poor, the basic issue is the ability of poor households to send migrants abroad. Stahl (1982, 883), for example, writes that "migration, particularly international migration, can be an expensive venture. Clearly it is going to be the relatively better-off households which will be more capable of [producing international migrants]."[25] Other analysts, however, suggest just the opposite. For instance, Burki (1984, 679), claims that in rural Pakistan, "it was primarily the very poorest, the bottom 20 percent, that contributed to the stream of [international] migration [to the Middle East]."

Four steps are taken in this chapter toward clarifying this issue: first, a poverty line is constructed for identifying the poor in rural Egypt; second, the effects of international remittances on the poor are evaluated; third, the ability of poor households to produce migrants is examined; and finally, the socioeconomic determinants of migration for the poor are analyzed.

## The Poor in Rural Egypt

At the outset it is necessary to identify who the "poor" are in rural Egypt. One conventional way to do this is to establish a poverty line, defined as the break-even amount of per capita household income needed to meet minimum food and nonfood requirements. Households with per capita incomes falling below such a line can then be designated as "poor."

Defining a poverty line is a difficult endeavor in any situation. In Egypt, the situation is compounded by the absence of consistent time-series data on rural prices for basic food and nonfood requirements. Without government data, one must resort to independent efforts to arrive at an acceptable poverty line.

The most reliable set of data for defining a poverty line comes from a series of consumer budget surveys undertaken by Egypt's Central Agency for Public Mobilization and Statistics in 1958/59, 1964/65, and 1974/75. The results of these government surveys can be updated by including data from a 1982 consumer budget survey conducted by the International Food Policy Research Institute (IFPRI).[26]

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[25] This view is shared by some researchers in Egypt, such as Khafagi (1983, 141), who notes that "[international] migrants own more land and come from higher income households than do nonmigrants."

[26] The results of the 1982 IFPRI study are *not* strictly comparable to the consumer budget surveys carried out by the Egyptian government because of differences in sampling techniques and procedures. However, the IFPRI sample was chosen on the basis of the reported variance of the observations of the 1974/75 Egyptian government survey. With 1,389 rural families, the IFPRI sample was large enough to have a probability of 0.997 that mean values for food expenditures would be within 4 percent of the true mean. For more on the IFPRI sample, see Alderman, von Braun, and Sakr (1982).

These data can be used to establish poverty lines for four benchmark years: 1958/59, 1964/65, 1974/75, and 1982 (Adams 1985). In Table 21, the poverty line—defined as the break-even level of per capita household income needed to meet basic food and nonfood requirements—increased from LE 1.29 (US $0.92) per month in 1958/59 to LE 9.72 (US $7.10) per month in 1982.

Unfortunately, no new consumer budget surveys have been undertaken in rural Egypt since 1982. However, it is possible to inflate the 1982 poverty-line figure by using the annual rate of inflation for rural Egypt between 1982 and 1986, estimated at 25 percent by the U.S. Agency for International Development (USAID).[27] This means that at the time of the survey, the poverty line for per capita household income was LE 23.72 (US $17.32) per month.

Given the character of the data, it should be emphasized that this method of defining a poverty line has at least two major limitations.[28] First, because there are no accurate consumer price indices for rural Egypt, it is difficult to estimate increases in the cost of living for that area. Official government price indices for the Egyptian countryside systematically underestimate price increases in such areas as food and housing.[29] Second, whereas this poverty line is based on consumer *expenditure* behavior, data from the 1986/87 survey is based on consumer *income* behavior. That the income calculations in this study are based on predicted figures partially mitigates this problem. These predicted income figures should, in theory, provide a better reflection of permanent income, which itself is viewed as the more important determinant of actual consumption behavior.[30] Although the predicted income figures do take into account the saving or dissaving behavior of various income groups, the poverty line calculations do not. In all likelihood, the interaction of these factors reduces the number of households falling below the poverty line.[31]

## Effects of International Remittances on the Poor

It is now possible to compare the number of households falling below the poverty line when remittances are excluded and included. As before, in the latter situation only remittances from the 104 still-abroad migrant households are included.

Consistent with the framework of this study, this comparison focuses on only the direct, first-round effects of remittances on the number of households in poverty. Obviously, the indirect effects of remittances on rural wages and prices also affect the number (and character) of households living in poverty. However, given the controversy surrounding this subject area, it seems best to concentrate on the direct effects.

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[27] This USAID estimate of the annual rate of inflation in rural Egypt is cited in Sullivan (1990, Table 3). It is the same rate of inflation used in confidential World Bank reports.

[28] For a more comprehensive list of the problems involved in creating a poverty line for rural Egypt, see Adams (1985, 706).

[29] On this point, see Bruton (1983, 704) and Adams (1986, 207).

[30] The concept of permanent income (as opposed to "transient" income) originated in the work of Friedman (1957). For more recent work on this topic, see Deaton (1972) and Flavin (1981).

[31] As explained in footnote (19), it is also possible that using predicted income figures to calculate these changes in rural poverty may have the effect of *underestimating* the actual degree of increase in the incidence of poverty.

## Table 21—Poverty line for rural Egypt, 1958/59, 1964/65, 1974/75, and 1982

| Item | 1958/59 | 1964/65 | 1974/75 | 1982 |
|---|---|---|---|---|
| 1. Annual cost of minimum required diet per capita per year (LE) | 13.14 | 18.02 | 45.01 | 89.85 |
| 2. Ratio of food cost to total expenditures | 0.70 | 0.67 | 0.65 | 0.64 |
| 3. Poverty line per capita per year (LE) | 18.78 | 27.09 | 69.24 | 140.40 |
| 4. Family size in adult equivalent units | 4.15 | 4.37 | 4.98 | 5.06 |
| 5. Poverty line per household per year (LE) | 77.98 | 118.34 | 344.82 | 711.26 |
| 6. Poverty line per capita per month (LE) | 1.29 | 1.87 | 4.79 | 9.72 |
| 7. Percent of rural households below poverty line | 27.4 | 23.8 | 60.7 | 17.8 |

Source: Adapted from Richard H. Adams, Jr., "Development and Structural Change in Rural Egypt, 1952-1982," *World Development* 13 (June 1985): Table 1.

Notes: Row (1) is the market cost of the diet that satisfies the minimum daily per capita requirements (2,510 calories) for an adult equivalent unit (AEU) in Egypt, as established by the Food and Agriculture Organization of the United Nations, *The State of Food and Agriculture* (Rome: FAO, 1979).

Row (2) figures are obtained by calculating the ratios of food to total expenditures for that expenditure group falling closest to the poverty line. The ratios for 1958/59, 1964/65, and 1974/75 are cited in Samir Radwan, *Agrarian Reform and Rural Poverty in Egypt, 1952-1975* (Geneva: International Labour Organisation, 1977) p. 42.

Row (3) figures are obtained by dividing row (1) by row (2).

Row (4) figures for rural family size for 1958/59, 1964/65, and 1974/75 are derived from Egyptian population censuses; 1982 figures are from the International Food Policy Research Institute, "Egyptian Family Budget Survey," Washington, D.C. (mimeo). For all years, it is estimated that, on average, one person equals 0.830 AEUs; this is the ratio used by Samir Radwan and Eddy Lee, "The Anatomy of Rural Poverty, Egypt, 1977," World Employment Programme, International Labour Organisation, Geneva (mimeo), Table 5:2.

Row (6) figures are obtained by dividing row (5) by 12 months, and then dividing that sum by the appropriate rural family size, expresssed in actual family members.

Row (7) figures are obtained by calculating the total number of rural households with total food and nonfood expenditures below the poverty line.

LE 1 = US$0.73.

When remittances are excluded, the predicted incomes of 26.8 percent of the 1,000 households fall short of the per capita poverty line income of LE 23.72 (US$17.32) per month; thus those households can be classified as "poor." When remittances are included, this figure drops to 24.4 percent.

These estimates of the number of poor rural households are comparable to those recorded in Table 21 and those made by other sources. For example, Egyptian government estimates assigned 30-40 percent of all Egyptian households to poverty throughout the 1970s (Ikram 1980). Similarly, on the basis of their own poverty line calculations, Radwan and Lee (1986) estimated that 35 percent of all rural Egyptian households were poor in 1977. The estimates in Table 21 of the number of poor households in 1986/87 probably fall below these earlier estimates because of the factors noted above.

Although the most common way of determining the degree of poverty is to identify the number of households living below a poverty line, this approach ignores differences in income of those who fall short of the line. It is therefore useful to supplement this simple household-count measure with a more sophisticated measure, such as Sen's index of poverty, which not only counts the number of people living in poverty but also weighs the amounts by which their incomes fall short.[32]

| | Percent of Households below Poverty Line | Sen's Index of Poverty |
|---|---|---|
| 1,000 households ranked by predicted per capita income: | | |
| Excluding remittances | 26.8 | 0.102 |
| Including remittances | 24.4 | 0.091 |

The direct, first-round effect of international remittances on the poor is therefore positive but small. When remittances are included, the household count reveals a 9.8 percent decrease in the number of poor households, and Sen's index of poverty declines 12.0 percent.

These changes are a reflection of the small—but proportionate— number of poor households actually receiving international remittances. According to the data, 28 of 268 households (10.4 percent) classified as "poor" when remittances are excluded actually receive remittances when these transfers are included. For the sample as a whole, 104 of 1,000 households (also 10.4 percent) receive remittances. These numbers point to a key policy finding, namely, that poor households can and *do* produce international migrants. Households classified as poor when remittances are excluded produce *exactly* the same proportion (10.4 percent) of still-abroad migrants as the total sample of households.

This finding can be corroborated by referring to Table 16. Column (3) of this table shows that, when all 1,000 households are ranked on the basis of their predicted per capita income excluding remittances, the bottom income group of households supplies slightly more than its quintile share of still-abroad migrants. It is only the lower-middle-income households—the second and third quintiles—that do not supply their proportionate share, which causes remittances to have a negative impact on income distribution.

Another way to analyze the impact of international remittances on the poor is to identify the contribution of remittances to the incomes of the poor. This can be done by taking the 268 households classified as poor when remittances are excluded and comparing their incomes with and without remittances. Using this methodology, the data show that international remittances account for 14.7 percent of total predicted per capita income for the 268 poor households.

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[32] Sen's index of poverty represents a normalized weighted sum of the income gaps of the poor. It measures both the number of people existing below the poverty line and the weighted amounts by which the incomes of the poor fall short of the specified poverty line. It can be expressed as

$$p = (q/n)(1/z)\,[(z-m))(1-G)],$$

where q is the number of people in poverty, n is the total population size, z is the poverty line, m is the mean income of the poor, and G is the Gini coefficient of the distribution of income of the poor.

## Poor Households and International Migration

From a policy standpoint the critical question now becomes, Why do only 28 of the 268 households classified as poor have migrants who are still abroad? What, if any, are the socioeconomic characteristics of these 28 poor households that distinguish them from the 240 other poor households?

Several important differences between the two groups of households are revealed in Table 22. First, while the 28 poor households with still-abroad migrants have lower mean predicted per capita incomes, excluding remittances, than the 240 poor households without such migrants, on average, the former have more mean land (rented and owned). This suggests that assets—especially land—may be more important than predicted per capita income excluding remittances in enabling the poor to migrate. This may be true because of the considerable costs of international migration: during the study period it cost the average migrant LE 500 (US $365) to travel abroad in addition to the income he forfeited while searching for a job abroad.[33] Thus, poor households with more assets to draw upon may be better able to produce still-abroad migrants than poor households without such assets. The validity of this hypothesis will be investigated later.

Regarding the demographic structure of the households, Table 22 shows that the two groups are similar in all measures save one. In row (2) the 28 poor households with still-

### Table 22—Selected characteristics of poor households, with and without still-abroad migrants, 1986/87

| Household Characteristic | Poor Households with No Still-Abroad Migrants (N = 240) (1) | Poor Households with Still-Abroad Migrants (N = 28) (2) | t-Statistic (Two-Tailed) (3) |
|---|---|---|---|
| Income and assets | | | |
| Mean predicted per capita household income per month excluding remittances (LE) | 17.77 | 16.43 | -1.15 |
| Mean land farmed (rented and owned) in feddans | 0.28 | 0.50 | 1.46 |
| Demographic structure | | | |
| Mean number of males over 13 years in household | 2.10 | 2.54 | 1.45 |
| Mean proportion of males over 13 years in household | 0.22 | 0.23 | 0.51 |
| Mean proportion of females over 13 years in household | 0.28 | 0.27 | -0.36 |
| Mean proportion of household members below 10 years | 0.45 | 0.45 | 0.01 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: LE 1 = US$0.73. 1 feddan = 1.038 acres. N = 240 poor households without still-abroad migrants and 28 with such migrants.

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[33] Most of the migrants in this study traveled to Iraq on tourist visas and had to find a job upon arrival.

abroad migrants have more males over 13 years old per household than the 240 poor households without such migrants. It may be hypothesized that, among the poor, the presence of more males enables households to produce migrants.

## Determinants of International Migration for the Poor

To test the effect of these factors—land, predicted per capita income (excluding remittances), and males over 13 years old—on the ability of poor households to produce migrants, the analysis is broadened to ask, What is the ability of poor households to produce both once-abroad and still-abroad migrants?

This question can be addressed by using the poverty line (LE 23.72) to estimate two revised versions of migration equation (8) for different groups of income-stratified males. In the first revised equation, the dependent variabie becomes the probability of migration of 487 males from poor households. It can be expressed as

$$\begin{aligned} M_{ipk} = {} & AGE + MAR + EMP1 + EMP2 + EDUC1 + EDUC2 \\ & + LND + MALE13 + PREX + AGEHH + AGR + DIS, \end{aligned} \qquad (17)$$

where $M_{ipk}$ is the probability of migration of the i*th* individual in the p*th* poor household in the k*th* community. (The other variables are defined in Chapter 3, Table 12.)

In the second revised migration equation, the dependent variable becomes the probability of migration of 1,372 males from nonpoor households, that is, males from households with predicted per capita incomes (excluding remittances) of more than LE 23.72 per month. It can be expressed as

$$\begin{aligned} M_{ink} = {} & AGE + MAR + EMP1 + EMP2 + EDUC1 + EDUC2 \\ & + LND + MALE13 + PREX + AGEHH + AGR + DIS, \end{aligned} \qquad (18)$$

where $M_{ink}$ is the probability of migration of the i*th* individual in the n*th* nonpoor household in the k*th* community.

Like the original migration equation, equations (17) and (18) use a five-step logit regression, which is necessary because one of the variables (PREX) is estimated from other variables (EDUC, LND, and MALE13).

Tables 23 and 24 present the results of the equations for males from poor and nonpoor households. Since this analysis is concerned with the effect of three variables—LND, PREX, and MALE13—on the propensity of males to migrate, the discussion will focus on regressions (2), (3), and (4).

For poor males in regression (2) in Table 23 the variable LND is positively and significantly related to migration. However, the results are just the opposite for males above the poverty line: LND is negatively and significantly related to migration (Table 24).

Land assets are thus a statistically significant determinant of migration for both sets of males. Among the poor, the propensity to migrate is positively associated with land because some land assets are needed to meet the financial and opportunity costs of international migration. Among the nonpoor, however, the propensity to migrate is negatively associated with land assets because more land provides nonpoor males with increased economic opportunities and responsibilities at home.

## Table 23—Logit regression analysis of international migration for males from poor households

| Independent Variable | Stepwise Equations | | | | Full Equation |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Age of male (AGE)[a] | −0.071 | −0.070 | −0.070 | −0.072 | −0.071 |
| | (−4.787)** | (−4.772)** | (−4.696)** | (−4.867)** | (−4.653)** |
| Marital status of male (MAR) (one if married, zero otherwise) | 1.598 | 1.569 | 1.617 | 1.634 | 1.568 |
| | (3.805)** | (3.979)** | (4.105)** | (4.118)** | (3.717)** |
| Employment status of male (EMP1) (one if agricultural laborer, zero otherwise) | 0.430 | 0.513 | 0.433 | 0.404 | 0.496 |
| | (1.000) | (1.186) | (1.004) | (0.937) | (1.131) |
| Employment status of male (EMP2) (one if government worker, zero otherwise) | −0.093 | −0.079 | −0.124 | −0.129 | −0.055 |
| | (−0.252) | (−0.255) | (−0.399) | (−0.420) | (−0.146) |
| Age of household head (AGEHH)[a] | −0.037 | −0.041 | −0.038 | −0.036 | −0.038 |
| | (−3.743)** | (−3.986)** | (−3.251)** | (−3.664)** | (−3.245)** |
| Educational status of male (EDUC1) (one if no education, zero otherwise) | 0.079 | . . . | . . . | . . . | 0.108 |
| | (0.232) | | | | (0.316) |
| Educational status of male (EDUC2) (one if more than elementary school, zero otherwise) | 0.015 | . . . | . . . | . . . | 0.060 |
| | (0.038) | | | | (0.151) |
| Land farmed (rented and owned) (LND) | . . . | 0.221 | . . . | . . . | 0.238 |
| | | (1.788)* | | | (1.797)* |
| Number of males over 13 years in household (MALE13) | . . . | . . . | 0.015 | . . . | −0.029 |
| | | | (0.190) | | (−0.319) |
| Predicted per capita household income (excluding remittances) (PREX)[b] | . . . | . . . | . . . | 0.006 | 0.005 |
| | | | | (0.351) | (0.284) |
| Percent of agriculturalists[c] in village farming less than 0.5 feddan (AGR)[d] | 0.023 | 0.029 | 0.023 | 0.024 | 0.029 |
| | (1.552) | (1.905)* | (1.575) | (1.581) | (1.898)* |
| Distance of village from main road to Cairo (DIS) | 0.001 | 0.005 | 0.002 | 0.001 | 0.003 |
| | (0.050) | (0.305) | (0.127) | (0.072) | (0.181) |
| Constant | 0.036 | −0.269 | 0.018 | −0.075 | −0.388 |
| | (0.033) | (−0.251) | (0.017) | (−0.067) | (−0.320) |

Notes: Includes 487 males over 18 years of age. Numbers in parentheses are t-statistics (two-tailed). The dependent variable in the regression is migration (M). Poor households are defined as those with predicted per capita income (excluding remittances) of less than LE 23.72 (US$17.32) per month.

[a] For once-abroad and still-abroad migrants, ages of males (AGE) and ages of household heads (AGEHH) are those at the time of migration.

[b] Predicted per capita household income (excluding remittances) is calculated from equation (6).

[c] The term agriculturalists includes all those employed as either farmer/peasants or agricultural laborers.

[d] 1 feddan = 1.038 acres.

*Difference is significant at the .10 level.

**Difference is significant at the .05 level.

# Table 24—Logit regression analysis of international migration for males from nonpoor households

| Independent Variable | Stepwise Equations | | | | Full Equation |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Age of male (AGE)[a] | −0.045<br>(−6.041)** | −0.048<br>(−6.597)** | −0.047<br>(−6.419)** | −0.046<br>(−6.307)** | −0.046<br>(−6.041)** |
| Marital status of male (MAR) (one if married, zero otherwise) | 1.424<br>(6.786)** | 1.330<br>(6.767)** | 1.288<br>(6.423)** | 1.243<br>(6.274)** | 1.487<br>(6.669)** |
| Employment status of male (EMP1) (one if agricultural laborer, zero otherwise) | 1.482<br>(6.172)** | 1.338<br>(5.473)** | 1.458<br>(6.015)** | 1.457<br>(6.004)** | 1.354<br>(5.514)** |
| Employment status of male (EMP2) (one if government worker, zero otherwise) | 0.056<br>(0.240) | 0.193<br>(0.957) | 0.182<br>(0.909) | 0.162<br>(0.803) | 0.031<br>(0.133) |
| Age of household head (AGEHH)[a] | −0.023<br>(−4.322)** | −0.021<br>(−3.806)** | −0.022<br>(−3.516)** | −0.022<br>(−4.109)** | −0.022<br>(−3.064)** |
| Educational status of male (EDUC1) (one if no education, zero otherwise) | 0.178<br>(0.835) | . . . | . . . | . . . | 0.152<br>(0.708) |
| Educational status of male (EDUC2) (one if more than elementary school, zero otherwise) | 0.485<br>(1.861)* | . . . | . . . | . . . | 0.545<br>(2.066)** |
| Land farmed (rented and owned) (LND) | . . . | −0.147<br>(−3.027)** | . . . | . . . | −0.154<br>(−2.602)** |
| Number of males over 13 years in household (MALE13) | . . . | . . . | −0.031<br>(−0.480) | . . . | 0.026<br>(0.392) |
| Predicted per capita household income (excluding remittances) (PREX)[b] | . . . | . . . | . . . | −0.015<br>(−2.336)** | −0.001<br>(−0.040) |
| Percent of agriculturalists[c] in village farming less than 0.5 feddan (AGR)[d] | −0.008<br>(−1.040) | −0.011<br>(−1.351) | −0.009<br>(−1.133) | −0.009<br>(−1.177) | −0.009<br>(−1.199) |
| Distance of village from main road to Cairo (DIS) | −0.002<br>(−0.144) | −0.004<br>(−0.395) | −0.005<br>(−0.423) | −0.004<br>(−0.362) | −0.001<br>(−0.034) |
| Constant | 0.288<br>(0.489) | 0.887<br>(1.586) | 0.731<br>(1.295) | 1.270<br>(2.084)** | 0.417<br>(0.609) |

Notes: Includes 1,372 males over 18 years of age. Numbers in parentheses are t-statistics (two-tailed). The dependent variable in the regression is migration (M). Nonpoor households are defined as those with predicted per capita income (excluding remittances) of more than LE 23.72 (US$17.32) per month.

[a] For once-abroad and still-abroad migrants, ages of males (AGE) and ages of household heads (AGEHH) are those at the time of migration.

[b] Predicted per capita household income (excluding remittances) is calculated from equation (6).

[c] The term agriculturalists includes all those employed as either farmer/peasants or agricultural laborers.

[d] 1 feddan = 1.038 acres.

*Difference is significant at the .10 level.

**Difference is significant at the .05 level.

## Table 25—Relationship between international migration and land farmed for males from poor and nonpoor households

| Amount of Land Farmed[a] | Predicted Probability of Migration[b] | |
|---|---|---|
| | Poor Males | Nonpoor Males |
| (feddans) | (percent) | |
| 0.0 | 17.3 | 21.5 |
| 0.5 | 19.4 | 20.0 |
| 1.0 | 21.6 | 18.5 |
| 2.0 | 27.0 | 16.0 |
| 3.0 | 33.6 | 13.8 |
| 4.0 | 42.0 | 11.9 |

Notes: N - 487 for poor males and 1,372 for nonpoor males. 1 feddan = 1.037 acres. Land farmed includes land rented and owned. Poor households are defined as those with predicted per capita income (excluding remittances) of less than LE 23.72 (US$17.32) per month. Nonpoor households are those above that level.

[a] All independent variables are valued at the mean except for the amount of land farmed (rented and owned) by household.

[b] Predicted probability of migration (PR) is calculated from regression (2) in Tables 23 and 24 using the equation

$$PR = e^{\beta x}/(1 + e^{\beta x}),$$

where $\beta$ = the coefficient of logit regression and x = the value of the independent variable.

Table 25 extends this analysis by presenting a list of predicted probabilities of migration for different land values for poor and nonpoor males. In this table mean values are substituted for all independent variables in step (2) of equations (17) and (18), and values for the land variable are allowed to vary. For poor males the propensity to migrate increases sharply with land assets, rising from 17.3 percent for males from landless households to 42 percent for those from households with 4 or more feddans of land farmed.[34] However, for nonpoor males the relationship is reversed: the propensity to migrate decreases from 21.5 percent for males from landless households to 11.9 percent for those from households with 4 or more feddans of land farmed.

Returning to Table 23, the results from regression (4) show that for poor males the effect of predicted per capita income excluding remittances (PREX) on migration is positive and not statistically significant. These results are different from those recorded in regression (4) in Table 24, where the effect of PREX on migration is negative and statistically significant for nonpoor males.

Table 26 extends the analysis of the impact of income on migration by presenting a list of predicted probabilities of migration for different predicted per capita income values for poor and nonpoor males. These values are calculated from regression (4) of equations (17) and (18) using the procedures outlined above. For both groups of males the propensity to migrate varies only slightly with income. For poor males, it increases from 18.8 percent for males from households with a predicted per capita income excluding remittances of LE 10 (US $7.30) to 20.1 percent for males from households with a predicted per capita income of LE 20 (US $14.60). Similarly, for nonpoor males, it falls from 22.8 percent of those with predicted per capita incomes of LE 25 (US$18.25) to 15.6 percent for those with incomes of LE 50 (US $36.50).

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[34] According to the data, 68.4 percent of the males from poor households are landless. In contrast, only 10.2 percent of the males from poor households have land farmed (rented or owned) of more than 2 feddans.

## Table 26—Relationship between international migration and predicted per capita household income per month, excluding remittances, for males from poor and nonpoor households

| Predicted per Capita Income (Excluding Remittances)[a] | Predicted Probability of Migration[b] | |
|---|---|---|
| | Poor Males | Nonpoor Males |
| (LE) | (percent) | |
| 10 | 18.8 | ... |
| 15 | 19.4 | ... |
| 20 | 20.1 | ... |
| 25 | ... | 22.8 |
| 30 | ... | 21.1 |
| 40 | ... | 18.2 |
| 50 | ... | 15.6 |

Notes: N = 487 for poor males and 1, 372 for nonpoor males. Predicted per capita household income excluding remittances is calculated from equation (6). Poor households are defined as those with predicted per capita income (excluding remittances) of less than LE 23.72 (US$17.32) per month. Nonpoor households are those with income greater than LE 23.72. LE 1 = US$0.73.

[a] All independent variables are valued at the mean except predicted per capita household income per month excluding remittances.

[b] Predicted probability of migration (PR) is calculated from regression (4) in Tables 23 and 24 using the equation

$$PR = e^{\beta x}/(1 + e^{\beta x}),$$

where $\beta$ is the coefficient of logit regression and $x$ is the value of independent variables.

These figures serve to emphasize the point that the predicted per capita income status of the household before migration is not the most important determinant of migration for the poor.[35] Rather the results of Table 23 show that, for the poor, assets—here meaning land—are a more important determinant of migration than predicted income, excluding remittances. In this table the sign for the land variable is statistically significant, while that for predicted per capita income excluding remittances is not. When controlling for income, poor households with land assets have a higher propensity to produce migrants than households without land.

The data for regression (3) in Table 23 show that for poor males the number of household males over 13 years old (MALE13) is not significantly related to migration; the results are similar to those recorded in Table 24 for nonpoor males. As noted in Chapter 3, the method of data aggregation used in these equations may have brought about these results. The unit of analysis for these equations is the individual male. When the unit of analysis becomes that of the individual household, however, the results tend to support a positive relationship between the number of household males over 13 years of age and the propensity of a poor household to produce migrants.

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[35] Table 13 shows that predicted per capita income (excluding remittances) is also not a very important determinant of migration for the sample of all males over 18 years of age.

# 6

# THE ECONOMIC USES OF INTERNATIONAL REMITTANCES*

In the past many observers have taken a dim view of international remittances, primarily because they believe that the bulk of such monies are spent on personal consumption. For example, a 1977 Egyptian Development Plan says that "growing numbers of Egyptians work abroad for very high wages. . . . These individuals return to Egypt possessed of high purchasing power, which they individually direct not to savings and investment, but to flagrant and luxurious consumption" (cited in Keely and Tran 1989, 503). Lipton (1980, 12) in his review of remittance behavior maintains that "everyday [consumption] needs often absorb 90 percent or more of a village's remittances" and that "investment is only the fourth (and last) priority for remittances."

In more recent years, several empirical studies have refined these rather pessimistic conclusions. Gilani, Khan, and Iqbal (1981) found that Pakistani workers did indeed use international remittances to increase consumption (one-third of the migrant households reported increased expenditures on basic staples) and that most investment went to real estate and housing. Overall, 62 percent of remittance expenditure went to current consumption, 22 percent to real estate, 13 percent to direct investments, and 3 percent to financial investments. However, when the expenditure behavior of migrants was compared with that of a nonmigrant control group, the consumption propensities of the two groups did not differ significantly. These findings suggest that the perceived negative effects of international remittances on development are no different from the results that would have obtained had the poorer members of society become better off by some other means. As the findings of Gilani, Khan, and Iqbal (1981) underscore, the key point of analysis should not be the consumption and investment behavior of migrants, but rather the behavior of migrants in comparison with nonmigrants.

To extend this debate, in this chapter the expenditure behavior of a set of migrant households is compared with that of a control set of nonmigrants. Since all of the households are separated into quintiles on the basis of expenditure or income, it is possible to identify how remittance earnings affect the consumption and investment behavior of different income groups of migrants—rich, middle-income, and poor.

In this chapter the nature and representativeness of the data from round 2 of the 1986/87 household survey are analyzed, the predicted income and expenditure functions used in analyzing migrant and nonmigrant behavior are presented, and the choice of the functional form for the model is discussed. Finally, the model is specified and estimated and the empirical results are presented.

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*An earlier version of this chapter appears as "The Economic Uses and Impact of International Remittances in Rural Egypt," in *Economic Development and Cultural Change* 39 (July 1991).

## Representativeness of the Second Round Survey Data

In round 2 of the 1986/87 survey, 150 of the original 1,000 households were selected for interviewing: 75 from the income-stratified group of nonmigrant households and 75 from the once-abroad migrant households.[36] None of the households in the still-abroad migrant group were chosen for interviewing in round 2 because it seemed desirable to question only migrants themselves regarding remittance expenditures.[37] The goal was to select two comparable groups of income-stratified migrant and nonmigrant households so that the main difference between them was that the first group had received remittances and the second had not.

It is important at the outset to pinpoint how well the households selected in round 2 represent the households in the larger round 1 survey by comparing household characteristics (Table 27). The nonmigrant and once-abroad migrant households are statistically different in terms of household size and number of males over 13 years old in both rounds.[38] Nonmigrant households farm more land and have higher actual mean per capita incomes (excluding remittances) than once-abroad migrant households in both rounds, but these differences are not statistically significant. Despite the lack of statistical significance, these findings underscore the point that once-abroad migrant households were not wealthy before migration. As for consistency between the two rounds, Table 27 indicates that the households in round 2 are broadly representative of those in round 1.

In round 2, interviewing focused on household expenditure and investment behavior. Data were collected for 14 major categories of outlay and on several subdivisions within each category from both migrant and nonmigrant households (Table 28). The time base over which households were asked to recall outlays differed between categories. Once-abroad migrant households were surveyed over the same 14 major categories, and migrants were queried about outlays in each category since their return. Since all of the migrant workers in round 2 had returned home, their remittance earnings were treated as being either spent or invested.

Nonrecurring items on which once-abroad migrant households in round 2 spent their actual (not predicted) remittance earnings are presented in Table 29. Because of the difficulty of identifying the proportion of remittances spent on normal recurring expenses, migrant expenditures on food, drink, and clothing are not included in this table.

About 54 percent of actual remittances spent on nonrecurring items went to the construction or repair of houses. Another large share (about 21 percent) went to the purchase of land for agricultural or building purposes. The once-abroad migrant households in round 2 spent only small percentages of their remittances on vehicles or

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[36] The 150 households in round 2 were selected as follows. After the 661 nonmigrant households of round 1 were ranked from high to low on the basis of actual gross income, 1 nonmigrant household was chosen for interviewing in round 2 from each group of 9 households in round 1. Similarly, after the 235 once-abroad migrant households of round 1 were ranked from high to low on the basis of actual gross income including remittances, 1 migrant household was chosen for interviewing in round 2 from each group of 3 households in round 1.

[37] Since all of the once-abroad migrants in round 2 had returned home, their remittances were treated as being either spent or invested.

[38] Other analysis of the data also suggests that these two groups of households are statistically different in terms of household size and number of males over 13 years of age (Adams 1989, 49).

## Table 27—Selected characteristics of nonmigrant and once-abroad migrant households, 1986/87

| | Round 1 | | | Round 2 | | |
|---|---|---|---|---|---|---|
| **Variable** | **Non-migrant Households (N = 661)** | **Once-Abroad Migrant Households (N = 235)** | **t-Statistic (Two-Tailed)** | **Non-migrant Households (N = 75)** | **Once-Abroad Migrant Households (N = 75)** | **t-Statistic (Two-Tailed)** |
| Mean household size | 6.55 | 7.33 | -3.43** | 6.53 | 8.39 | -3.29** |
| Mean number of males over 13 years in household | 2.10 | 2.47 | -3.75** | 1.95 | 2.96 | -4.87** |
| Mean age of all males in household (years) | 25.62 | 22.43 | 3.83** | 24.92 | 22.19 | 1.62 |
| Mean education of males over 18 years in household (one if preparatory school or higher, zero otherwise) | 0.18 | 0.24 | -2.28 | 0.22 | 0.17 | 0.76 |
| Mean area of land farmed (feddans) | 1.07 | 0.67 | 1.88 | 1.19 | 0.71 | 1.06 |
| Actual mean annual per capita income (excluding remittances) in LE | 399.72 | 372.60 | 1.29 | 461.39 | 375.75 | 1.12 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: Land farmed includes land rented and owned. 1 feddan = 1.038 acres. LE 1 = US$0.73.

**Difference between households is significant at the .05 level.

mercantile activities. A more detailed analysis of these patterns of remittance expenditure follows.

## Predicted Income and Expenditure Functions

In order to compare the expenditure behavior of migrant and nonmigrant households in round 2, one theoretical and two methodological issues need to be addressed. The theoretical problem concerns the issue of fungibility. Since money can be spent in many different ways, simply observing that remittances are not used to encourage investment, for example, does not mean that remittances cannot be credited with this result. International remittances may well have freed other resources for expenditure on investment (Stark 1980). To overcome this problem, remittance and nonremittance income are combined for each once-abroad migrant household, and expenditures out of this total income (remittance and nonremittance) are reported.

As for the two methodological problems, in this study it is not known what the annual incomes of the 75 once-abroad migrant households in round 2 would have been had they not had someone abroad. Similarly, it is not known what the expenditures of these migrant households would have been. Therefore, it is necessary to *predict* what the incomes and expenditures of these households would have been without remittances.

## Table 28—Expenditure items included in round 2 of the 1986/87 household survey

| Expenditure Item | Period of Recall for Nonmigrants | Period of Recall for Migrants |
|---|---|---|
| Food, drink | One month | Same |
| Shoes, clothes | One Year | Same |
| Education, school supplies | One year | Same |
| Medical, health expenses | One year | Same |
| Agricultural expenses | One year | Same |
| Pilgrimage to Mecca | Five years | Same, plus period since migration |
| Marriage expenses | Five years | Same, plus period since migration |
| Household goods (radio, television) | Five years | Same, plus period since migration |
| Housing costs (building, repair) | Five years | Same, plus period since migration |
| Land purchases (building, farmland) | Five years | Same, plus period since migration |
| Agricultural investment | Five years | Same, plus period since migration |
| Vehicle purchases (car, taxi) | Five years | Same, plus period since migration |
| Store, restaurant purchases | Five years | Same, plus period since migration |
| Other investment | Five years | Same, plus period since migration |

## Table 29—Expenditure on nonrecurring items as a percent of total actual remittance earnings of once-abroad migrants in round 2 of survey, 1986/87

| Item | Percent of Total Actual Remittance Earnings |
|---|---|
| Built new house | 42.5 |
| Repaired house | 11.4 |
| Purchased agricultural land | 11.2 |
| Marriage expenses | 10.8 |
| Purchased land for building | 9.3 |
| Purchased car or taxi | 4.7 |
| Opened or expanded store | 3.0 |
| Purchased television | 2.3 |
| Purchased radio | 1.0 |
| Purchased refrigerator | 0.9 |
| Other | 2.9 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: N = 75. These figures reflect expenditures of actual (not predicted) remittance earnings.

In pursuit of these ends, a procedure similar to that followed in Chapter 3 is used. The parameters predicting annual gross household income excluding remittances (INC) are estimated from data for the 75 nonmigrant households in round 2. The equation used is

$$\mathrm{INC} = \mathrm{LND} + \mathrm{EDUC} + \mathrm{MALE13} + \mathrm{FEM13}, \tag{19}$$

where

LND = land farmed (rented and owned) by household,
EDUC = mean education of male household members over 18 years old (one if preparatory school or higher, zero otherwise),
MALE13 = number of males over 13 years old in the household, and
FEM13 = number of females over 13 years old in the household.

On the expenditure side, the parameters predicting annual gross household expenditures excluding remittances (EXP) are also estimated from the 75 households in round 2 that had not sent a migrant abroad. The equation used is

$$\mathrm{EXP} = \mathrm{HS} + \mathrm{CHILD5} + \mathrm{MAR} + \mathrm{INPC} + \mathrm{SQINPC}, \tag{20}$$

where

HS = size of household,
CHILD5 = number of children less than 5 years old as a proportion of household size,
MAR = a dummy for marriage expenses (one if marriage costs were incurred in the last five years, zero otherwise),
INPC = log of per capita annual income, and
SQINPC = square of the log of per capita annual income.

The parameters from equations (19) and (20) are then applied to the 75 once-abroad households in round 2 in order to predict their gross annual income and expenditures *without* remittances. In this procedure the variables MALE13 from equation (19) and HS from equation (20) are assumed to include migrants from the once-abroad households.

Finally, it is necessary to determine the income and expenditures of the 75 once-abroad households *with* remittances. Following the framework of this study, remittances for each once-abroad household in round 2 are valued taking total migrant income earned abroad minus travel, food, and housing costs abroad.[39] Since all of these households have had a migrant abroad within the past five years, an annual figure is reached by dividing the resulting remittance figure for each household by the number of years that household had a migrant abroad. If, for example, a household had a migrant abroad for two years and the migrant's net remittance earnings were LE 5,000 (US$3,650), then the annual remittance income of that migrant would be LE 2,500 (US$1,825).

Annual gross household income, including remittances, for the 75 once-abroad households in round 2 is then determined by adding predicted household income and remittance income for each year. Annual gross household expenditures including remittances for these once-abroad households are calculated in a similar fashion by adding predicted expenditures to remittance expenditures for each year.

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[39] For more on this point, see equation (1) in Chapter 2.

In equation (19) it is hypothesized that all four variables—LND, EDUC, MALE13, and FEM13—are positively correlated with gross annual household income.

In equation (20) it is hypothesized that HS, CHILD5, and INPC are positively correlated with gross annual household expenditure. Because marriage costs are extremely high in this area, the dummy variable MAR is entered to capture the effects of marriage on household expenditure.

Tables 30 and 31 summarize the parameter results obtained from using equations (19) and (20) to estimate predicted gross annual household income and expenditures without remittances. In Table 30, all of the coefficients are significantly different from zero at the 5 percent level. As expected, three of the four coefficients are positively correlated with predicted gross household income excluding remittances. However, as before, the coefficient EDUC is significantly and *negatively* correlated.[40] The reasons for this paradoxical relationship have already been explained in Chapter 3 and the Appendix.

In Table 31 all of the coefficients are also significantly correlated with predicted gross annual household expenditures excluding remittances, and only the coefficient for the squared income term (SQINPC) is negative, as expected.

The results of efforts to calculate annual per capita income and expenditures for nonmigrant and once-abroad migrant households in round 2 are summarized in Table 32. The predicted mean annual per capita income, excluding remittances, of once-abroad households is less than that of nonmigrant households. Yet when remittances are included, income of once-abroad households is 67 percent higher than that of nonmigrant households. Similarly, when remittances are included, the predicted mean annual per capita expenditures of once-abroad households are 142 percent higher than those of nonmigrant households.

Table 32 shows that international remittances change the expenditure patterns of once-abroad migrant households. Mean annual per capita expenditures (including remittances) for migrant as opposed to nonmigrant households are higher by 31 percent for consumption, 231 percent for durables, and 1,458 percent for investment.

Because it is important to this analysis, the classification of expenditures in Table 32 into three categories—consumption, durables, and investment—merits some discussion. The distinction between these three categories of expenditures lies in the difference between current and future wants. Consumption refers to expenditures to meet immediate needs: food, clothing, education, medical, pilgrimage, and marriage costs.[41] Durables

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[40] These results are identical to those obtained by running equation (19) on the 661 nonmigrant households in round 1. Such an equation yields results in which all of the coefficients are significantly correlated with predicted gross household income excluding remittances. Three of the coefficients are positively correlated with predicted income excluding remittances, and the coefficient for EDUC is negatively correlated with the dependent variable. The $R^2$ in this equation is 0.551.

[41] After much thought, it was decided to include expenses incurred for pilgrimages and marriage under the category of consumption. Unlike investment items, expenditure on pilgrimages and marriage meet current—not future—needs. And unlike durable items, pilgrimage and marriage do not provide perceptible future *economic* returns to the individual. Marriage costs include costs of ceremony, jewelry, and bride price.

## Table 30—Regression to estimate predicted gross annual household income (excluding remittances) in round 2

| Variable | Regression Coefficient | t-Ratio |
|---|---|---|
| Land farmed (rented and owned) by household (LND) | 329.525 | 9.294** |
| Mean education of male household members over 18 years (one if preparatory school or higher, zero otherwise) (EDUC) | -797.968 | -2.371** |
| Number of males over 13 years in household (MALE13) | 377.906 | 2.950** |
| Number of females over 13 years in household (FEM13) | 360.193 | 2.675** |
| Constant | 892.271 | 2.460** |
| $R^2 = 0.585$ | | |

Notes: Regression is based on 75 nonmigrant households of round 2. The parameters are used to estimate predicted gross annual household income, excluding remittances, of the once-abroad migrant households in round 2.

**Difference is significant at the .05 level.

refers to expenditures to meet longer-term needs, such as household goods and housing. Finally, investment refers to those outlays for which the individual expects (or hopes) to enjoy some economic return in the future: land, equipment, and commercial enterprises.

Whereas it may be easy in theoretical terms to distinguish between consumption, durables, and investment, on a practical level the difference between them becomes blurred. Consider, for example, an expenditure of key importance to this study: housing. From the standpoint of society, housing should be classified as a durable expenditure because it benefits the individual without any major social externalities. Yet from the

## Table 31—Regression to estimate predicted gross annual household expenditures (excluding remittances) in round 2

| Variable | Regression Coefficient | t-Ratio |
|---|---|---|
| Household size (HS) | 189.029 | 6.145** |
| Number of children less than five years as proportion of household size (CHID5) | 1,117.431 | 1.881* |
| Marriage dummy (one if marriage in household in last five years, zero otherwise) (MAR) | 511.550 | 2.354** |
| Log of per capita annual income (INPC) | 2.119 | 4.956** |
| Square of log of per capita annual income (SQINPC) | -0.001 | -4.414** |
| Constant | -805.163 | -2.566** |
| $R^2 = 0.437$ | | |

Notes: Regression is based on 75 nonmigrant households of round 2. The parameters are used to estimate predicted gross annual household expenditures, excluding remittances, of the once-abroad migrant households in round 2.

*Difference is significant at the .10 level.

**Difference is significant at the .05 level.

## Table 32—Annual per capita income and expenditures for nonmigrant and once-abroad migrant households in round 2

| Income/Expenditure | Nonmigrant Households (N = 75) | Once-Abroad Migrant Households (N = 75) | t-Statistic (Two-Tailed) |
|---|---|---|---|
| | (LE) | | |
| Mean annual per capita income | | | |
| Excluding remittances | 461.4 | 391.1[a] | 0.90 |
| Including remittances | 461.4 | 772.2[b] | -3.50** |
| Mean annual per capita expenditures including remittances | | | |
| Total | 257.7 | 623.9[c] | -7.24** |
| Consumption[d] | 187.2 | 246.5 | -6.16** |
| Durables[e] | 63.9 | 211.9 | -5.30** |
| Investment[f] | 6.6 | 102.9 | -4.80** |

Notes: Predicted income and expenditure values recorded here may not sum up to actual figures presented earlier. LE 1 = US$0.73.

[a] This is a predicted value estimated from equation (19).

[b] This is a predicted value calculated by adding the predicted income results from equation (19) and net remittance income per year (see the text).

[c] This is a predicted value calculated by adding the predicted expenditure results from equation (20) and net remittance expenditures per year (see the text).

[d] Consumption includes expenditures on food, drink, clothing, education, medical care, pilgrimages, and marriage.

[e] Durables include expenditures on household goods and housing.

[f] Investment includes expenditures on land, agricultural investment, vehicles, stores, and other items.

**Difference is significant at the .05 level.

standpoint of the individual, housing expenses should be classified as an investment, since new or improved housing offers possible future economic returns to the individual. Because expenditures on housing are of vital importance to once-abroad migrant households, housing is analyzed in this chapter as both a durable and an investment good.

## Choice of Functional Form

To pursue the analysis, a proper functional form must be chosen for the model. The selected form should do several things. First, it must provide a good statistical fit to a wide range of commodities. Second, because the focus is on expenditure and consumption relationships, the chosen form must have a slope that is free to change with expenditure. Since, in this study, expenditure elasticities as well as marginal propensities to consume need to be calculated, a model specification that imposes the same slope (or marginal budget share) for all levels of expenditure would not be useful. What is needed is a functional form that mathematically allows for rising, falling, or constant marginal propensities to consume over a broad range of expenditure levels. Third, the chosen function should conform with the criterion of additivity; to be internally consistent, the sum of the marginal propensities for all commodities should equal unity.[42]

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[42] For more on this point, see Prais and Houthakker (1971, 84-86).

Because it serves all of these purposes, the semilog ratio function is selected as the basic functional form:

$$C_i/EXP = a + b\ (\log EXP), \tag{21}$$

where

$C_i$ = expenditure on good i,
EXP = total expenditure,
a = constant.
b = the parameter to be estimated for good i.

In using this function to compare the expenditure behavior of households with different incomes, various socioeconomic factors other than income must be taken into account. Part of the observed differences in expenditure behavior may be due, for example, to differences in family size or (in this sample) to the presence of a worker abroad and the length of time spent abroad. These variables for household characteristics need to be built into the function in a way that allows them to shift both the intercept and the slope of the Engel curve. Therefore, let HS be the variable for household size, as in earlier chapters, and let MNS (months abroad) be the variable for length of time abroad of migrants. Also, let MIG be a dummy variable for migration (1 for migrants, 0 otherwise), which allows expenditure behavior to differ according to classification as a migrant or nonmigrant household. The complete model is

$$C_i/EXP = a + b\ (MIG) + c\ (\log EXP) + d\ (MIG)(\log EXP) + e\ (HS) + f\ (MIG)(HS) + g\ (MNS). \tag{22}$$

From this equation the expenditure elasticity for the *ith* good ($\xi_i$) and the average and marginal budget shares (ABS and MBS, respectively) can be derived as follows:

$$\text{when } MIG = 0,\ \xi_i = [(EXP/CON)(c)] + 1; \tag{23}$$

$$\text{when } MIG = 1,\ \xi_i = [(EXP/CON)(c + d)] + 1; \tag{24}$$

$$ABS_i = CON_i/EXP; \text{ and} \tag{25}$$

$$MBS_i = (ABS)(\xi_i). \tag{26}$$

For the individual household, these terms are evaluated at the mean household values for consumption (CON) and expenditure (EXP). But when comparing across quintiles, CON and EXP are assigned their mean values for the relevant quintiles.

Although both income and expenditure data were collected for all households in round 2, the analysis here emphasizes expenditure data for two reasons. First, the income data proved to be noisy, and there was often a large (and unexplained) discrepancy between income and expenditure, even after savings were accounted for.[43] Second, in situations like this, expenditure is likely to be a better indicator of *permanent* income, which itself is viewed as the more important determinant of consumption behavior (Friedman 1957; Flavin 1981). This consideration is particularly relevant for migrant households, whose annual incomes fluctuate considerably depending on whether a worker is currently abroad. Under these conditions, total consumption expenditure is likely to provide a better measure of the households' perceptions of their future income than the actual incomes recorded in the surveys.

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[43] See, for example, Table 32, where mean annual per capita income including remittances for once-abroad migrant households is LE 772.2, but mean annual per capita expenditures including remittances for once-abroad households only sum up to LE 623.9 (or about 80.8 percent of mean annual per capita income).

## Specification and Estimation of the Model

Using equation (22) to estimate the model yields the following formulation:

$$C^{con,dur,inv}/EXP = MIG + \log EXP + (MIG)(\log EXP) + HS + (MIG)(HS) + MNS, \qquad (27)$$

where

$C^{con,dur,inv}$ = annual per capita household expenditure on consumption, durables, or investment,
EXP = total annual per capita household expenditure,
MIG = migration dummy variable (one if migrant household, zero otherwise),
log EXP = log of total annual per capita household expenditure,
(MIG)(log EXP)= migration dummy variable x log of total annual per capita household expenditure,
HS = household size,
(MIG)(HS) = migration dummy variable x size of household
MNS = months spent abroad by migrant (zero if no migrant).

In this specification, the dependent variable is expressed in per capita terms to facilitate comparisons between households. As explained earlier, the independent expenditure variable (EXP) is also expressed in per capita terms, so that the model permits family size to influence both the intercept and the slope of the various commodity functions.

After two households are eliminated because of incomplete data (one migrant, one nonmigrant), the parameters of equation (27) are estimated for the 148 households in round 2. The parameters are estimated separately for expenditure, income, and each category of outlay: consumption, durables, and investment. The basic estimation technique used is ordinary least squares (OLS).

The results are summarized in Table 33. When expenditure data are used, 11 of the 18 coefficients are significantly different from zero at the 10 percent level. With income data, 10 of the 18 coefficients are significant at this level of confidence.

With consumption as the numerator of the dependent variable, the share of consumption in total expenditures decreases as household size increases. This relationship is highly significant using both expenditure and income data, which suggests that economies of scale do exist for consumption items such as food, drink, and clothing. Both the months abroad and the migration dummy terms are negative and significant when using expenditure and income data. This suggests, first, that once-abroad migrants who stayed

## Table 33—Regression analysis of household expenditures and income in round 2, selected variables

| | Regression Based on Household Expenditure Data | | Regression Based on Household Income Data | |
|---|---|---|---|---|
| **Variable** | **Regression Coefficient** | **t-Statistic** | **Regression Coefficient** | **t-Statistic** |
| Consumption | | | | |
| Household size (HS) | -0.019 | -2.780** | -0.025 | -3.856** |
| Migrant household size (MIG)(HS) | 0.010 | 1.088 | 0.026 | 2.705** |
| Months abroad (MNS) | -0.004 | -3.501** | -0.003 | -3.135** |
| Migration dummy (MIG) | -0.614 | -1.748* | -1.460 | -3.125** |
| Annual per capita expenditures (EXP) | -0.289 | -7.180** | . . . | . . . |
| Annual per capita income (Y) | . . . | . . . | -0.278 | -9.056** |
| Migrant annual per capita expenditures (MIG)(EXP) | 0.090 | 1.661* | . . . | . . . |
| Migrant annual per capita income (MIG)(Y) | . . . | . . . | 0.210 | 3.216** |
| Constant | 2.489 | 10.445 | 2.339 | 11.815** |
| | $R^2$ = 0.664<br>N = 148 | | $R^2$ = 0.503<br>N = 148 | |
| Durables | | | | |
| Household size (HS) | 0.014 | 1.932* | 0.001 | 0.165 |
| Migrant household size (MIG)(HS) | -0.012 | -1.188 | 0.008 | 0.744 |
| Months abroad (MNS) | 0.002 | 1.990** | 0.002 | 2.031** |
| Migration dummy (MIG) | 1.510 | 4.095** | -0.540 | -1.019 |
| Annual per capita expenditures (EXP) | 0.253 | 5.966** | . . . | . . . |
| Annual per capita income (Y) | . . . | . . . | 0.009 | 0.255 |
| Migrant annual per capita expenditures (MIG)(EXP) | -0.253 | -4.436** | . . . | . . . |
| Migrant annual per capita income (MIG)(Y) | . . . | . . . | 0.078 | 1.020 |
| Constant | -1.275 | -5.096** | 0.088 | 0.382 |
| | $R^2$ = 0.270<br>N = 148 | | $R^2$ = 0.090<br>N = 148 | |
| Investment | | | | |
| Household size (HS) | 0.005 | 1.055 | 0.003 | 0.827 |
| Migrant household size (MIG)(HS) | -0.004 | -0.602 | 0.001 | 0.088 |
| Months abroad (MNS) | 0.002 | 2.460** | 0.001 | 2.227** |
| Migration dummy (MIG) | -0.112 | -0.448 | -0.654 | -2.247** |
| Annual per capita expenditures (EXP) | 0.037 | 1.285 | . . . | . . . |
| Annual per capita income (Y) | . . . | . . . | 0.008 | 0.418 |
| Migrant annual per capita expenditures (MIG)(EXP) | 0.022 | 0.567 | . . . | . . . |
| Migrant annual per capita income MIG)(Y) | . . . | . . . | 0.104 | 2.487** |
| Constant | -0.214 | -1.260 | -0.054 | -0.428 |
| | $R^2$ = 0.170<br>N = 148 | | $R^2$ = 0.201<br>N = 148 | |

Note: Regressions are based on 148 households, 74 nonmigrant and 74 once-abroad migrant.
*Significant at the .10 level.
**Significant at the .05 level.

abroad longer spend a smaller proportion of their income on consumption; second, once-abroad migrants spend a smaller share on consumption than nonmigrants at a given level of expenditure. These are key findings because they show that once-abroad migrants do not spend a disproportionate share of their remittance earnings on consumption goods.

Moreover, with consumption as the numerator, the negative and significant terms for annual per capita expenditures indicate that as total expenditures rise, the share of spending on consumption falls. This relationship is expected. Adding together the relevant coefficients to arrive at the relationship for migrant expenditures [(EXP) + (MIG)(EXP)] yields a similar result (not shown), which is also statistically significant. As migrant annual per capita expenditures rise, the share of once-abroad migrant spending on consumption falls.

With durables as the numerator of the dependent variable, household size is positive and significant when expenditure data are used. This suggests that at a given level of expenditure, larger households spend a higher proportion on such durable items as household goods and housing. When expenditure data are used, the migration dummy variable and the months-abroad term are also positive and highly significant. This suggests that not only do once-abroad migrant households spend a larger share on durables than nonmigrants at a given level of expenditure, but that migrants who stayed abroad longer spend a larger share on durables. Because housing represents the bulk of durable expenditures (88 percent for once-abroad migrant households), it is reasonable to conclude that at any given level of expenditure migrants spend more on housing than nonmigrants.

With investment as the numerator of the dependent variable, the months-abroad term is positive and highly significant using both expenditure and income data. This suggests that once-abroad migrants who stayed abroad longer also spend a higher proportion on investment at a given level of expenditure or income. Given this relationship, it is disturbing to note that the migration dummy variable is *negative* and significant when income data are used, which suggests that once-abroad migrant households actually devote a *smaller* share of their income to investment at a given level of income. However, when the relevant income coefficients are added together [(Y) + (MIG)(Y)] to arrive at the relationship for migrant income (not shown), the results indicate that as migrant income rises, so does the proportion of income spent on investment.

## Empirical Results: Remittances and Household Behavior

To compare the spending behavior of nonmigrant and once-abroad migrant households at similar expenditure (income) levels, all 148 households in round 2 are ranked in quintiles on the basis of expenditure (or income) *including* remittances. These households are then divided into nonmigrant and once-abroad migrant groups, and the regression results from Table 33 are used to calculate expenditure elasticities and marginal budget shares for the various quintiles.[44]

In this comparison, quintile means are determined by aggregating mean individual household values. Once-abroad migrant households are evaluated on the basis of their expenditures or income *including* remittances. The main difference then, between the once-abroad migrant and the nonmigrant households for any quintile should be that the former received remittances within the last five years and the latter did not. Spending behavior of migrant and nonmigrant quintiles is compared for consumption expenditures in Table 34, for durable expenditures in Table 35, and for investment expenditures in Table 36.

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[44] Total annual per capita expenditures (income), including remittances, for migrant households are calculated using predicted functions, and the results of these predicted functions exceed actual expenditures (income) by about 10 percent. Consequently, in Tables 34, 35, and 36 marginal budget shares for consumption, durables, and investment for once-abroad migrant households do not sum to unity.

Using expenditure data, Table 34 shows that marginal budget shares to consumption decline with expenditure for both nonmigrant and once-abroad migrant households.

### Table 34—Consumption expenditure behavior of nonmigrant and once-abroad migrant households in round 2, analyzed using expenditure and income data

| Percent of 148 Households Ranked by per Capita Expenditures Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Expenditure | Mean of per Capita Consumption | Expenditure Elasticity | Marginal Budget Share to Consumption |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 130.58 | 121.89 | 0.69 | 0.64 |
| Second | 32.43 | 217.41 | 169.23 | 0.63 | 0.49 |
| Third | 13.51 | 354.35 | 248.66 | 0.59 | 0.41 |
| Fourth | 13.51 | 551.86 | 303.88 | 0.47 | 0.26 |
| Highest | 1.35 | 875.00 | 575.00 | 0.56 | 0.37 |
| All | 100.00 | 255.97 | 185.09 | 0.60 | 0.43 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | 1.35 | 145.77 | 145.00 | 0.71 | 0.71 |
| Second | 8.11 | 247.21 | 150.86 | 0.53 | 0.32 |
| Third | 25.67 | 364.16 | 169.77 | 0.38 | 0.18 |
| Fourth | 27.03 | 543.02 | 250.82 | 0.37 | 0.17 |
| Highest | 37.84 | 941.43 | 322.05 | 0.15 | 0.05 |
| All | 100.00 | 618.49 | 247.43 | 0.28 | 0.12 |

| Percent of 148 Households Ranked by per Capita Income Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Income | Mean of per Capita Consumption | Income Elasticity | Marginal Budget Share to Consumption |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 191.84 | 129.49 | 0.59 | 0.40 |
| Second | 27.03 | 319.27 | 180.31 | 0.51 | 0.29 |
| Third | 16.21 | 462.83 | 190.23 | 0.32 | 0.13 |
| Fourth | 8.11 | 676.57 | 283.98 | 0.34 | 0.14 |
| Highest | 9.46 | 1,839.59 | 335.54 | -0.53 | -0.10 |
| All | 100.00 | 465.40 | 185.09 | 0.30 | 0.12 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | . . . | . . . | . . . | . . . | . . . |
| Second | 13.51 | 377.32 | 151.15 | 0.31 | 0.12 |
| Third | 24.32 | 510.31 | 188.02 | 0.25 | 0.09 |
| Fourth | 32.43 | 709.75 | 233.18 | 0.15 | 0.05 |
| Highest | 29.73 | 1,220.97 | 355.33 | 0.04 | 0.01 |
| All | 100.00 | 768.30 | 247.43 | 0.14 | 0.04 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Note: LE 1 = US$0.73.

Table 35—Durable expenditure behavior of nonmigrant and once- abroad migrant households in round 2, analyzed using expenditure and income data

| Percent of 148 Households Ranked by per Capita Expenditures Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Expenditure | Mean of per Capita Durables | Expenditure Elasticity | Marginal Budget Share to Durables |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 130.58 | 8.69 | 4.80 | 0.32 |
| Second | 32.43 | 217.41 | 41.17 | 2.34 | 0.44 |
| Third | 13.51 | 354.35 | 94.26 | 1.95 | 0.52 |
| Fourth | 13.51 | 551.86 | 226.75 | 1.62 | 0.66 |
| Highest | 1.35 | 875.00 | 300.00 | 1.74 | 0.60 |
| All | 100.00 | 255.97 | 64.19 | 2.01 | 0.50 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | 1.35 | 145.77 | 18.00 | 3.05 | 0.38 |
| Second | 8.11 | 247.21 | 52.74 | 2.19 | 0.47 |
| Third | 25.67 | 364.16 | 117.64 | 1.78 | 0.58 |
| Fourth | 27.03 | 543.02 | 172.01 | 1.80 | 0.57 |
| Highest | 37.84 | 941.43 | 351.28 | 1.68 | 0.63 |
| All | 100.00 | 618.49 | 214.13 | 1.73 | 0.60 |

| Percent of 148 Households Ranked by per Capita Income Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Income | Mean of per Capita Durables | Income Elasticity | Marginal Budget Share to Durables |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 191.84 | 24.40 | 1.07 | 0.14 |
| Second | 27.03 | 319.27 | 29.83 | 1.10 | 0.10 |
| Third | 16.21 | 462.83 | 127.72 | 1.03 | 0.29 |
| Fourth | 8.11 | 676.57 | 137.49 | 1.05 | 0.21 |
| Highest | 9.46 | 1,839.59 | 155.46 | 1.11 | 0.09 |
| All | 100.00 | 465.40 | 64.19 | 1.07 | 0.15 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | . . . | . . . | . . . | . . . | . . . |
| Second | 13.51 | 377.32 | 90.59 | 1.04 | 0.25 |
| Third | 24.32 | 510.31 | 100.68 | 1.04 | 0.21 |
| Fourth | 32.43 | 709.75 | 222.23 | 1.03 | 0.32 |
| Highest | 29.73 | 1,220.97 | 354.28 | 1.03 | 0.30 |
| All | 100.00 | 768.30 | 214.13 | 1.03 | 0.29 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.
Note: LE 1 = US$0.73.

Although consumption here includes more than just food, this finding is broadly consistent with Engel's Law. However, the nature of this decline for once-abroad migrant households is interesting; their marginal budget shares to consumption drop dramatically between the first and second quintiles. Migrant households in the lowest quintile devote 71 percent of incremental expenditure to consumption items, but those in the next group spend only 32 percent and those in subsequent groups spend even

## Table 36—Investment expenditure behavior of nonmigrant and once-abroad migrant households in round 2, analyzed using expenditure and income data

| Percent of 148 Households Ranked by per Capita Expenditures Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Expenditure | Mean of per Capita Investment | Expenditure Elasticity | Marginal Budget Share to Investment |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 130.58 | 0.00 | . . . | . . . |
| Second | 32.43 | 217.41 | 7.02 | 2.14 | 0.07 |
| Third | 13.51 | 354.35 | 11.43 | 2.14 | 0.07 |
| Fourth | 13.51 | 551.86 | 21.24 | 1.96 | 0.08 |
| Highest | 1.35 | 875.00 | 0.00 | . . . | . . . |
| All | 100.00 | 255.97 | 6.69 | 2.41 | 0.06 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | 1.35 | 145.77 | 0.00 | . . . | . . . |
| Second | 8.11 | 247.21 | 0.00 | . . . | . . . |
| Third | 25.67 | 364.16 | 27.48 | 1.49 | 0.11 |
| Fourth | 27.03 | 543.02 | 70.67 | 1.28 | 0.17 |
| Highest | 37.84 | 941.43 | 180.19 | 1.19 | 0.23 |
| All | 100.00 | 618.49 | 94.34 | 1.24 | 0.19 |

| Percent of 148 Households Ranked by per Capita Income Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Income | Mean of per Capita Investment | Income Elasticity | Marginal Budget Share to Investment |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 191.84 | 1.53 | 2.03 | 0.02 |
| Second | 27.03 | 319.27 | 10.00 | 1.26 | 0.04 |
| Third | 16.21 | 462.83 | 6.75 | 1.57 | 0.02 |
| Fourth | 8.11 | 676.57 | 18.29 | 1.31 | 0.04 |
| Highest | 9.46 | 1,839.59 | 8.58 | 2.77 | 0.01 |
| All | 100.00 | 465.40 | 6.69 | 1.56 | 0.02 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | . . . | . . . | . . . | . . . | . . . |
| Second | 13.51 | 377.32 | 4.61 | 1.67 | 0.02 |
| Third | 24.32 | 510.31 | 45.09 | 1.09 | 0.10 |
| Fourth | 32.43 | 709.75 | 54.85 | 1.11 | 0.09 |
| Highest | 29.73 | 1,220.97 | 218.49 | 1.05 | 0.19 |
| All | 100.00 | 768.30 | 94.34 | 1.07 | 0.13 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Note: LE 1 = US$0.73.

smaller proportions. These data suggest that as soon as migrant households have satisfied their immediate consumption needs, they begin to devote larger shares of incremental expenditure to nonconsumption items.

These results lead to two conclusions. First, except for the lowest expenditure quintile, incremental budget shares to consumption for once-abroad migrant households are surprisingly low—32 percent or less. This suggests that these migrant households do not spend large amounts on items such as food, clothing, pilgrimages, marriage, and education. Second, except for the lowest expenditure group, marginal budget shares to consumption for all quintiles are *lower* for migrant than for nonmigrant households. This means that at any given level of expenditure migrant households are actually less likely to spend additional increments of expenditure on consumption than their nonmigrant counterparts.

When spending on durables is analyzed using expenditure data in Table 35, all quintiles of nonmigrant households have expenditure elasticities greater than 1.0. This indicates that durables are luxury goods for nonmigrant households, and marginal budget shares to durables rise as expenditures increase. These relationships also hold true for once-abroad migrant households: their marginal budget shares to durables increase from 38 to 63 percent. With only one exception, however, marginal budget shares to durables are higher for all quintiles of migrant households, compared with nonmigrants. At the mean, once-abroad migrant households devote 60 percent of their incremental expenditure to durables.

The data in Table 35 reflect the importance of one particular durable good—housing—for migrant households. As noted before, once-abroad migrant households spend more than 88 percent of their mean annual per capita durable expenditures on housing (building and repair). Observations in the field suggest that these expenditures are important for migrants from all quintiles. The first priority for most migrants is to replace traditional mud-brick houses with red-brick houses.

Table 36 shows that marginal budget shares to investment for nonmigrant households do not rise with expenditure levels; rather, they remain very low at all levels of outlay. However, marginal budget shares to investment for once-abroad migrant households rise sharply as expenditures increase. With only one exception, marginal budget shares to investment of migrant households are higher at all quintile levels than those of nonmigrants.

At first glance, these findings regarding the investment behavior of migrant households seem to contradict those reported in Table 33. With investment as the numerator of the dependent variable, the regression results for the migration dummy variable in Table 33 show that, at a given level of expenditure (or income), once-abroad migrant households devote a smaller share to investment than nonmigrant households. However, as expenditures (incomes) rise, so does the proportion of migrant expenditure on investment.[45] Because the expenditures, including remittances, of once-abroad migrant households exceed those of nonmigrant households, migrants may spend less on investment at any given level of expenditure but still devote larger shares to investment. Indeed, Table 36 shows that for migrants, only one quintile (the second lowest) has a marginal budget share to investment that is below that of nonmigrants.

Because once-abroad migrant households spend such a high proportion of their expenditures on housing, an alternative way of comparing the investment behavior of migrant and nonmigrant households is presented in Table 37. In this table all expenditures on housing (building and repair) are classified as "investment" rather than as

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[45] With investment as the numerator of the dependent variable, Table 33 shows that the sum of the coefficients for EXP and (MIG)(EXP) is positive (0.059). The sum of the coefficients for the relevant income variables (Y) and (MIG)(Y) is also positive (0.112).

## Table 37—Investment expenditure behavior of nonmigrant and once-abroad migrant households in round 2, where all expenditures on housing are classified as investment

| Percent of 148 Households Ranked by per Capita Expenditures Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Expenditure | Mean of per Capita Investment | Expenditure Elasticity | Marginal Budget Share to Investment |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 130.58 | 3.36 | 11.77 | 0.30 |
| Second | 32.43 | 217.41 | 40.05 | 2.50 | 0.46 |
| Third | 13.51 | 354.35 | 92.50 | 2.06 | 0.54 |
| Fourth | 13.51 | 551.86 | 216.92 | 1.70 | 0.67 |
| Highest | 1.35 | 875.00 | 248.78 | 1.97 | 0.56 |
| All | 100.00 | 255.97 | 59.48 | 2.19 | 0.51 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | 1.35 | 145.77 | 7.50 | 6.39 | 0.33 |
| Second | 8.11 | 247.21 | 17.86 | 4.83 | 0.35 |
| Third | 25.67 | 364.16 | 128.63 | 1.78 | 0.63 |
| Fourth | 27.03 | 543.02 | 215.25 | 1.70 | 0.67 |
| Highest | 37.84 | 941.43 | 501.90 | 1.52 | 0.81 |
| All | 100.00 | 618.49 | 282.66 | 1.61 | 0.73 |

| Percent of 148 Households Ranked by per Capita Income Including Remittances | Percent of 74 Nonmigrant Households | Mean of per Capita Income | Mean of per Capita Investment | Income Elasticity | Marginal Budget Share to Investment |
|---|---|---|---|---|---|
| (quintile) | | (LE) | | | |
| Nonmigrant households (N = 74) | | | | | |
| Lowest | 39.19 | 191.84 | 20.40 | 1.23 | 0.13 |
| Second | 27.03 | 319.27 | 33.75 | 1.23 | 0.13 |
| Third | 16.21 | 462.83 | 116.97 | 1.10 | 0.28 |
| Fourth | 8.11 | 676.57 | 136.94 | 1.12 | 0.23 |
| Highest | 9.46 | 1,839.59 | 129.93 | 1.34 | 0.10 |
| All | 100.00 | 465.40 | 59.48 | 1.19 | 0.15 |
| Once-abroad migrant households (N = 74) | | | | | |
| Lowest | . . . | . . . | . . . | . . . | . . . |
| Second | 13.51 | 377.32 | 76.51 | 1.12 | 0.23 |
| Third | 24.32 | 510.31 | 126.23 | 1.10 | 0.27 |
| Fourth | 32.43 | 709.75 | 252.82 | 1.07 | 0.38 |
| Highest | 29.73 | 1,220.97 | 536.91 | 1.05 | 0.46 |
| All | 100.00 | 768.30 | 282.66 | 1.07 | 0.39 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.
Note: LE 1 = US$0.73.

"durables." From the perspective of the individual, outlays on housing represent an investment to the extent that they offer some expected return in the future.

With housing classified as an investment good, marginal budget shares to investment for nonmigrant households rise sharply with expenditure level (Table 37). Yet marginal budget shares to investment of once-abroad migrant households rise even faster. In fact, once-abroad migrant households in the top quintile devote more than 80 percent of their marginal budget shares to investment. With only one exception, marginal budget shares to investment are as high or higher at all quintile levels of expenditure for migrant as opposed to nonmigrant households.

Taken together, the findings in Tables 36 and 37 show that migrant households *do* invest their remittance earnings. Regardless of whether expenditures on housing are classified as "durable" or "investment" goods, migrants tend to devote larger shares of their expenditure increments to investment than do nonmigrants. When controlling for expenditure, migrants are actually *more* likely than nonmigrants to invest additional increments of expenditure.[46]

It is, of course, essential to identify more precisely the character of migrant investment, especially when such investment does *not* include housing expenses. According to the data, when housing items are excluded, one-half of all once-abroad migrant households (37 of 74 households) report expenditures on investment. Most of this migrant investment goes to the purchase of land (either for agriculture or building) (Table 38). Once-abroad migrant households devote approximately 73 percent of their total per capita investment expenditures to land and much smaller shares to other items, such as purchases of stores (9.2 percent), vehicles (8.6 percent), and irrigation pumps (3.3 percent).[47] Survey data show that only one migrant household bought a taxi and none purchased a tractor.

Table 38 shows that migrant expenditure on investment is dominated by households in the highest expenditure groups. Once-abroad migrant households in the fourth and top quintile groups account for 78 percent of all migrant investing households (29 of 37 households). Moreover, once-abroad migrant households in these top two quintile groups account for more than 92 percent of total per capita migrant expenditures on investment. This concentration of investment is not surprising given the lumpiness of the preferred type of investment: land. It is also not surprising that these wealthy migrant households also account for *all* investment expenditures on vehicles and irrigation pumps. They evidently possess the means to pursue a wider portfolio of investments.

It is useful to examine the reasons other than expenditure that may explain why investment is dominated by once-abroad migrant households in the top quintile. Means tests of social and demographic differences between the 28 once-abroad migrant households in the top expenditure quintile and the 46 once-abroad migrant households in the other expenditure quintiles suggest the following. Mean household size for the 28 households in the top quintile is significantly smaller (6.1 persons) than that for the 46 households in the other quintiles (9.7 persons). Mean age of household head in the top quintile is also significantly less (41.4 years) than that for the other quintiles (48.8 years). However, none of the following variables are significantly different between the two groups of once-abroad migrant households: mean education of males over 18 years;

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[46] This finding does not take into account the role of savings. Because of methodological problems associated with collecting accurate data on savings, this study does not attempt to compare savings propensities for nonmigrant and once-abroad migrant households. If, however, marginal propensities to save were found to be higher for nonmigrant than migrant households, this finding regarding the investment behavior of migrant households would have to be modified.

[47] This pattern of investment is quite similar to that of nonmigrant households in round 2. They devote 72.9 percent of their total per capita investment expenditures to land, 16.9 percent to irrigation pumps, and 10.1 percent to the purchase of commercial enterprises. None of the nonmigrant households bought vehicles, including taxis or tractors.

## Table 38—Per capita expenditure on investment by item for once-abroad migrant households in round 2

| Percent of 148 Households Ranked by per Capita Expenditures, Including Remittances | Percent of Total per Capita Migrant Investment in | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Agri-cultural Land | Land for Building | Tractor | Irrigation Pump | Private Vehicle or Taxi | Store | Other[a] | All |
| (quintile) | | | | | | | | |
| Lowest | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Second | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Third | 2.1 | 1.5 | 0.0 | 0.0 | 0.0 | 3.2 | 1.1 | 7.8 |
| Fourth | 0.0 | 18.8 | 0.0 | 0.9 | 0.0 | 0.0 | 1.6 | 21.4 |
| Highest | 25.5 | 25.2 | 0.0 | 2.4 | 8.6 | 6.0 | 3.0 | 70.8 |
| All | 27.6 | 45.5 | 0.0 | 3.3 | 8.6 | 9.2 | 5.7 | 100.0 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Note: N = 74 once-abroad migrant households.

[a] Other includes investment in high-yielding seeds, fertilizer, and pesticide.

males over 13 years as a proportion of household size; mean number of migrant months spent abroad; or mean actual monthly income earned abroad.

Why do once-abroad migrants choose to invest such a large proportion of their remittance earnings in land? There are two reasons. First, on the whole, the once-abroad migrants in this study are not wealthy (see Table 16). When ranked on the basis of their income before migration, once-abroad migrants are disproportionately drawn from the lower and middle quintiles. Since they were not rich before migration, the evidence suggests that when they returned these migrants tended to spend their remittance earnings in a conservative fashion.[48] This can be seen by considering how the investments of migrants tend to follow their occupational backgrounds. Fifty-three percent of the once-abroad migrants in round 2 are farmers or agricultural laborers, 18 percent are government bureaucrats, and only 10 percent are merchants. Thus, the great majority know only agriculture or government bureaucracy; they lack the necessary mercantile skills to either open a store or start a taxi business. In their investments they therefore tend to avoid unfamiliar areas (such as business) in favor of committing their earnings to that which they know best (land).[49]

Second, the attraction of land investment arises from the general investment environment of the study area. Within the last decade the international migration of workers has sparked a major increase in land prices throughout Egypt. For example, between 1980 and 1986 the average price of a feddan of agricultural land in the study area increased by 600 percent, rising from LE 2,000 to LE 12,000 (US $1,460 to $8,760). As a result, rates of return on land investment have clearly exceeded those found in other categories of investment. For instance, real rates of return on agricultural land in the area have averaged about 9.5 percent per year during 1980-86.[50] By means of comparison, average annual real rates of return on most small-farm crops in Egypt have been negative over this same period.[51] Detailing the reasons for such negative real rates of return on Egyptian crops would go far beyond the scope of this study, but the factors involved are closely related to the pattern of pricing, investment, and institutional policies pursued by the Egyptian state.[52] As a result of these policies, few once-abroad migrants in the study area saw fit to invest in agricultural items other than land, such as new high-yielding seeds and fertilizer. Several migrants in the top expenditure quintiles did buy new agricultural machinery (gasoline-powered pumps) to irrigate their fields. But no once-abroad migrants bought tractors or other mechanized agricultural equipment, probably because they decided that the returns to such investment were too small.

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[48] Because they rank households in different ways, there is no contradiction between the findings of Tables 16 and 38. Table 16 ranks once-abroad migrant households on the basis of predicted income *excluding* remittances and shows that these households were not rich before migration. Table 38 ranks once-abroad migrant households on the basis of predicted expenditures *including* remittances and reveals that investment is dominated by once-abroad migrants from the top expenditure groups. Yet when the once-abroad migrants from the fourth and top expenditure groups in Table 38 are ranked on the basis of predicted income *excluding* remittances, the data show that these households were also not rich before migration.

[49] Writing about the manner in which migrants invest their remittance earnings, Stahl (1989, 369) observes that "it is naive to expect that overseas work will transform a poor peasant . . . into an industrial entrepreneur."

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[50] In all likelihood, real rates of return on building land in the area have been even higher. However, such rates of return are notoriously difficult to calculate, because they are based on the transfer of relatively small pieces of land. All rate-of-return calculations assume a 25 percent annual rate of inflation in rural Egypt during 1980-86.

[51] Although certain fruits and vegetables do yield positive real rates of return, these are not ordinarily grown by small farmers. At present, the only small crop that yields positive real rates of return in Egypt is *berseem* (Egyptian clover). See Adams (1986, 118-120) and Cuddihy (1980, 85-98).

[52] For a detailed examination of the factors affecting rates of return on Egyptian crops, see Ikram (1980), Cuddihy (1980), and Adams (1986).

## 7

# CONCLUSIONS AND POLICY RECOMMENDATIONS

## Who Goes to Work Abroad and Why?

Observers interested in the issues of migration and remittances in the developing world have often assumed that it is the young and educated who tend to become migrants. These observers have also assumed that migrants—especially international migrants—tend to come from richer households. However, some surprising findings emerge from the migration model used in this study.

First, in examining the socioeconomic determinants of migration for different groups of rural Egyptian males—all males over 18 years of age, males from poor households, and males from nonpoor households—the results suggest that education may not necessarily be positively correlated with migration. When the migration model is estimated for the sample of all males over 18 years, the probability of migration is highest for agricultural laborers, the least educated group in the study. This finding—that *less* education is actually associated with migration—parallels the results of other studies in rural Third World areas (Bilsborrow et al. 1987, for example). More research is needed to clarify this point.

Second, an important focus of this study is to pinpoint the effects of income on migration. The results suggest that the predicted per capita income of the household before migration is not the most important determinant of migration; rather, employment status in agriculture combined with lack of land access is the leading determinant. In rural Egypt, those who work in agriculture but have no land of their own are most likely to go to work abroad. For agricultural laborers, poverty of land combines with employment in agriculture to "push" people abroad.

Third, the results of the migration model suggest that migration is not a life-cycle phenomenon. According to some observers, families with older household heads—and thus more "age-eligible" males for migration—should produce more migrants. However, when the migration model is estimated for all males over 18 years, the age of household head variable has a negative and significant effect on migration. This same result is obtained when the model is estimated for males from poor and nonpoor households. These are unexpected outcomes, indicating that households with older heads are actually less likely to produce international migrants.

## International Remittances and the Poor

This study uses predicted income equations to evaluate the impact of international remittances on poverty and income distribution. Using this framework, the study shows that international remittances have a small, but positive, effect on poverty. Poverty-line calculations indicate that the number of poor households declines by 9.8 percent when predicted per capita household income includes international remittances. Such remittances account for 14.7 percent of the total predicted per capita income of poor households.

These changes in poverty are a reflection of the small—but proportionate—number of poor households who actually receive remittances. According to the data, 28 of 268 households (10.4 percent) classified as "poor" when remittances are excluded receive remittances. For the sample as a whole, 104 of 1,000 households (10.4 percent) receive remittances. In other words, the proportion of households receiving remittances is the same for poor households as it is for the sample as a whole. This is a key policy finding, because it shows that poor households can and *do* produce international migrants.

In examining the socioeconomic determinants of international migration for the poor, the study finds that land assets are a more important determinant of migration than predicted per capita household income. Among the poor, the propensity to migrate is positively and significantly associated with land farmed (rented and owned) because some land assets are needed to meet the financial and opportunity costs of international migration. The propensity of the poor to migrate is positively related to predicted per capita household income excluding remittances, but this relationship is not significant. For poor males, the propensity to migrate increases only slightly with predicted per capita household income.

## International Remittances and Income Inequality

Whereas international remittances have a positive effect on poverty, they have a *negative* effect on income distribution in this survey. When remittances are included in predicted per capita household income, the Gini coefficient, a measure of inequality, increases by 24.5 percent from 0.233 to 0.290.

The reasons for this paradoxical outcome are as follows. When remittances are included, the lowest income quintile produces its proportionate share of still-abroad migrants; the second and third income quintiles do not. Moreover, when remittances are included, the two top income quintiles produce a disproportionate share of still-abroad migrants—more than 53 percent combined. It is these variations in the number of migrants produced by different income groups—and not differences in either migrant earnings abroad or marginal propensities to remit—that cause remittances to have a negative effect on rural income distribution.

However, this result is not inevitable. The data clearly show that remittances had a negative impact on income distribution because at the time of the survey most still-abroad migrants came from the upper-income groups. Yet data for the once-abroad category of migrants indicate that at an earlier time poor and lower-middle income households produced just as many migrants as households in the upper-income groups. Had the distribution of households sending migrants abroad been as evenly distributed as it was in the past, it is likely that the effects of remittances on rural income distribution would also have been more equitable.

Decomposing the sources of income inequality shows that remittance income makes only a small contribution to overall income inequality. Although remittance income is itself distributed very unequally, it has only a small share in total income. According to the data, agricultural income is the dominant source of overall income inequality.

## The Economic Uses of International Remittances

Three conclusions emerge from the analysis of the economic uses of remittances. First, contrary to the findings of other studies, migrant households do not spend a large proportion of their remittance earnings on personal consumption. For example, Lipton's finding that "everyday [consumption] needs often absorb 90 percent or more of a village's remittances" is at odds with the data presented here.[53] In this study, budget shares allocated to consumption items such as food, clothing, education, medical, pilgrimage, and marriage expenses by once-abroad migrant households are much lower than 90 percent. At the mean level of expenditure, migrant households devote only 12 percent of their increments in expenditure to consumption. Instead of spending their remittance earnings on consumption, once-abroad migrant households tend to view their remittance earnings as a temporary stream of income, one not to be "squandered" on consumer goods.

Second, this analysis confirms the findings of other studies concerning the large amount of remittance money that goes into housing.[54] In this study fully 53.9 percent of remittance earnings spent on nonrecurring items goes to the construction or repair of houses. Expenditures on housing dominate the category of durables. And once-abroad migrant households exhibit a higher propensity than nonmigrant households to spend on durables, mostly housing. With only one exception, marginal budget shares to durables are higher for all expenditure quintiles of migrant than nonmigrant households. Migrant households tend to view the temporary income flows from abroad as an opportunity to tackle one of their most immediate concerns, namely, replacing their crowded, traditional mud-brick houses with more modern red-brick dwellings.

Third, the empirical results suggest that it is wrong to claim that "migrants don't invest" or that "investment is only the fourth (and last) priority for remittances" (Lipton 1980, 12). This study not only clearly shows that migrants invest, but that they actually exhibit a *higher* propensity to invest than do their nonmigrant counterparts. Using expenditure data and controlling for level of expenditure, marginal budget shares to investment for once-abroad migrant quintiles are consistently higher than those of nonmigrants. Most of this investment goes to land: approximately 73 percent of total per capita expenditures on investment by once-abroad migrant households went to the purchase of agricultural or building land. From the standpoint of the individual migrant, land represents a good investment. The value of land tends to exceed the rate of inflation, and for most peasant migrants, it represents the best type of investment available to them.

The propensity of migrants to invest their remittance earnings raises several important policy issues. If the Egyptian government is anxious to channel the flow of remittance monies into rural investments *other* than land, it needs to take some concrete policy actions. In order to encourage migrant investment in agricultural production, the government must continue its efforts to raise the purchase prices for key government-controlled crops: cotton, wheat, and rice. Once the private rates of return on these crops become more favorable, peasant migrants are likely to begin investing a larger share of their remittance monies in elements of the new agricultural technology, such as high-yielding seeds, fertilizers, and agricultural equipment. To the extent that such investment increases the incomes of peasant farmers, it may well provide an economic stimulus for other sectors of the rural, nonfarm economy. As the incomes of peasant farmers rise, they will have more to spend on health, service, and transport activities. The expansion of these and similar locally based activities could well provide a broad economic stimulus for developing rural Egypt from the local level up. The challenge to make more productive use of international remittances clearly exists, but the policy instruments for meeting that challenge need to be identified and implemented.

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[53] Lipton's findings are based largely on internal remittances earned by migrants (rural to urban) working within India (Connell et al. 1976; Lipton 1980). In all likelihood, these internal remittance earnings represent a much smaller proportion of household income than the international remittance earnings analyzed here. Nevertheless, the marginal budget shares to consumption for migrant households in this study are still *much* lower than the 90 percent reported by Lipton.

[54] See, for example, Gilani, Khan, and Iqbal (1981) and Lipton (1980).

# APPENDIX: RETURNS TO EDUCATION IN RURAL EGYPT

Rates of return to education in rural Egypt can be analyzed using both descriptive statistics and multivariate regression analysis.

## Descriptive Statistics

An important reason for low private rates of return to education in Egypt may be the character of the income or wage structure. Table 39 presents the mean monthly income of all income and wage earners by educational level in rural Egypt.[55] Since the analysis focuses on rates of return, these data are expressed in terms of *actual* individual income or wages (excluding remittances) received in Egypt. Table 39 does not include any income (wages) earned outside of Egypt.

The income and wage structure in rural Egypt is highly unusual. Unlike most developing-country situations, in rural Egypt neither mean income nor mean wages increase with education. In fact, for both categories of earners there is no positive difference between those with no education and those with a university degree. According to the data, the mean actual income of earners with no education is 8.8 percent higher than that of those with a university education. Similarly, the mean actual wages of earners with no education is 27.6 percent higher.

There are two reasons for this perverse relationship between income and education. First, in rural Egypt educated people are generally "forced"—through lack of employment alternatives in the private sector—to accept secure but low-paying government jobs. In the cities, educated Egyptians are able to couple their low-paying government posts with income from a secondary source (such as taxi driving), but in the countryside the dearth of private employment opportunities makes such "moonlighting" much more difficult. Second, the continued international migration of villagers—and especially the migration of agricultural workers—has helped boost the wages of uneducated field hands.[56] According to the data, real wages for agricultural laborers in the study area increased at a rate of 6 percent a year during the period 1979-86. At the same time, real wages of government employees fell approximately 10 percent a year.[57] The net result

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[55] Wage earners (N=577) includes all those employed as agricultural laborers, government workers, artisans, private-sector workers, or professionals. Income earners (N=1,501) includes all those employed as farmers/peasants or merchants.

[56] In this area of rural Egypt social custom and tradition normally prevent educated people from hiring themselves out as agricultural laborers (see Adams 1986, 39-40).

[57] These calculations regarding the movement of real wages assume a 25 percent annual rate of inflation during the period 1979-86. For agricultural wages, average nominal wages received by an agricultural worker working all day (8 a.m.-12 p.m. and 2 p.m.-4 p.m.) in the study area increased from LE 0.77 (US$0.53) in 1979 to LE 5.00 (US$3.65) in 1986. For government wages, average nominal wages in the study area for a new high-school-educated government employee increased from LE 20 to LE 50 (US$15 to US$36) during this period; average nominal wages for a similarly educated middle-aged government employee increased from LE 45 to LE 110 (US$33 to US$80).

## Table 39—Income and wage differentials by education, 1986/87

| Education Level | Income Earners[a] | | Wage Earners[b] | |
|---|---|---|---|---|
| | Actual Mean Income/Month Excluding Remittances | Number of Observations | Actual Mean Wages/Month Excluding Remittances | Number of Observations |
| | (LE) | | (LE) | |
| No school | 119.56<br>(62.51) | 981 | 135.93<br>(76.32) | 216 |
| Less than six years schooling | 141.39<br>(92.42) | 300 | 127.82<br>(71.77) | 161 |
| Elementary or preparatory school graduate | 106.93<br>(72.93) | 29 | 94.04<br>(57.86) | 25 |
| High school graduate | 98.35<br>(69.45) | 145 | 95.12<br>(68.84) | 133 |
| University graduate | 109.80<br>(73.45) | 41 | 106.54<br>(75.50) | 37 |
| Other | 81.60<br>(40.50) | 5 | 81.60<br>(40.50) | 5 |

Source: Survey of International Migration and Remittances in Rural Egypt, International Food Policy Research Institute, 1986/87.

Notes: N = 1,501 income earners and 577 wage earners. Numbers in parentheses are standard deviations of mean. LE 1 = US$0.73.

[a] Income earners include all those employed as farmer/peasants and merchants.

[b] Wage earners include all those employed as agricultural laborers, government workers, artisans, private-sector workers, or professionals.

of these two factors has been a "scissors-type" series of changes in the rural Egyptian income structure: rising real incomes for uneducated agricultural workers and falling real incomes for educated government workers.

## Multivariate Analysis

In the literature, rates of return to education are typically calculated from income or wage data using the Mincerian earnings function (Mincer 1974):

$$Y = f(S, EX, EX^2), \tag{28}$$

where

$Y$ = log of annual income or wages,
$S$ = years of formal schooling completed,
$EX$ = experience of the individual, measured as Age - S - 6, and
$EX^2$ = square of experience of the individual.

Because the focus here is on rates of return to education in rural Egypt, it seems best to express the dependent variable in terms of actual individual income (excluding remittances) received in Egypt. The dependent variable therefore does not include any income earned outside of Egypt. On the right-hand side of the equation, a land variable is added to capture the effect of landholdings on rural income. The model then becomes

$$ACTINC = S + EX + EX^2 + LNDMALE, \quad (29)$$

where

ACTINC = log of actual annual income (excluding remittances), and
LNDMALE = land farmed (rented and owned) per number of male household members over 18 years old.

In this exercise, rates of return to education are identified according to the level of schooling: primary, high school, and university. The single schooling variable (S) can therefore be replaced with a set of schooling dummy variables representing different intervals of education. This model can be expressed as

$$\begin{aligned} ACTINC = SCH1 + SCH2 + SCH3 + SCH4 \\ + SCH5 + EX + EX^2 + LNDMALE, \quad (30) \end{aligned}$$

where

SCH1 = no schooling,
SCH2 = less than 6 years of schooling (can read and write),
SCH3 = completed elementary or preparatory school (6 or more years but less than 10 years),
SCH4 = completed high school (12 years), and
SCH5 = completed university (16 years).

Equations (29) and (30) are estimated in two different ways. First, in order to analyze the effects of education on income, both equations are estimated for all males over 18 years of age who received an actual income in Egypt (excluding remittances). Nonmigrant and once-abroad migrant males are included here, but still-abroad migrants are excluded because they received no income in Egypt during the time of the survey. Second, in order to pinpoint the effect of education on wages, equations (29) and (30) are estimated for all male wage earners over 18 years old who received wages in Egypt at the time of the survey. Nonmigrant and once-abroad migrant male wage earners are again included, but still-abroad migrants and nonwage earners (peasants and farmers, for example) are not.

The results of equations (29) and (30) are shown in Table 40. Columns (1) and (3) of this table present the results for income and wage earners when the single schooling variable is used. In both equations, EX and $EX^2$ are significant and of the expected signs. However, in both equations the values for the single schooling term (S) are very low and statistically insignificant.

These results are important for three reasons. First, it is unusual to run a Mincer-type equation and have a single schooling term that is statistically insignificant. Virtually all other studies of Mincer-type rates of return to education in developing countries have found that the single term, "years of schooling," has a positive *and* significant effect on

## Table 40—Earnings functions for income earners and wage earners, 1986/87

| Variable | Income Earners[a] (N = 1,501) | | Wage Earners[b] (N = 577) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Years of schooling (S) | 0.0038<br>(0.931) | ... | 0.0083<br>(1.110) | ... |
| Schooling less than six years (SCH2) | ... | 0.067<br>(1.836)* | ... | -0.070<br>(-0.933) |
| Elementary or preparatory school graduate (SCH3) | ... | -0.275<br>(-2.611)** | ... | -0.354<br>(-2.291)** |
| High school graduate (SCH4) | ... | 0.019<br>(0.326) | ... | 0.069<br>(0.693) |
| University graduate (SCH5) | ... | 0.230<br>(2.415)** | ... | 0.290<br>(1.977)** |
| Experience (EX) | 0.058<br>(13.842)** | 0.058<br>(13.672)** | 0.060<br>(6.995)** | 0.065<br>(7.399)** |
| Square of experience ($EX^2$) | -0.000<br>(-13.772)** | -0.001<br>(-13.643)** | -0.001<br>(-5.738)** | -0.001<br>(-6.170)** |
| Land farmed (rented and owned) per male household member over 18 years (LNDMALE) | 0.128<br>(11.780)** | 0.127<br>(11.709)** | 0.082<br>(2.652)** | 0.079<br>(2.570)** |
| Constant | 3.732<br>(52.853)** | 3.729<br>(52.961)** | 3.590<br>(24.816)** | 3.574<br>(24.886)** |
| $R^2$ | 0.202 | 0.210 | 0.137 | 0.149 |

Notes: N = 1,501 income earners and N = 577 wage earners. Numbers in parentheses are t-statistics (two-tailed). Columns (1) and (3) are based on equation (29) in the text, which has a single variable for schooling; columns (2) and (4) are based on equation (30), which has a set of four dummy variables representing various levels of schooling. The dependent variable is log of actual income excluding remittances (ACTINC).

[a] Income-earners include all those employed as farmer/peasants and merchants.

[b] Wage earners include all those employed as agricultural laborers, government workers, artisans, private-sector workers, or professionals.

*Difference is significant at the .10 level.

**Difference is significant at the .05 level.

income and wages.[58] The results in Table 40, which suggest that this is not the case in rural Egypt, may be caused by a process of negative selectivity. In rural Egypt education may not have a statistical effect on income or wages simply because the "best and brightest" have already left for the cities or abroad.[59] Nevertheless, the results are so paradoxical that they point to the need for further research into the effect of education on income and wages in rural Egypt.

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[58] See, for example, the studies cited in Psacharopoulos (1985).

[59] As noted at the outset, this analysis of rates of return to education does *not* consider the effect of income (wages) received outside of Egypt when remittances are included. If, however, the analysis were revised to take into account the remittance income (wages) earned by migrants, then it is likely that the rates of return to education would be higher. As shown in Table 5, high-school educated males have a higher propensity to migrate, which suggests that rates of return to education (in general) and high-school education (in particular) would be higher if these income (wage) calculations included remittances.

Second, the results for the single schooling term in Table 40 suggest that the private rate of return to the typical year of schooling (undifferentiated by level) for both income and wage earners in rural Egypt is less than 1.0 percent. Such a figure is much lower than the 3-10 percent private rates of return to the typical year of schooling reported by recent studies in Pakistan (Guisinger, Henderson, and Scully 1984) and rural Burkina Faso (Ram and Singh 1988). It is also much lower than the 8-13 percent private rates of return to the typical year of schooling reported by Psacharopoulos (1985, Table 3) in his review of Mincer-type rates of return to education in 25 developing countries.

Third, it should be noted that all of the private annual rates of return recorded in Table 40 reflect gross, not net, returns to education. Although the opportunity costs of schooling in rural Egypt are unknown, studies of the opportunity costs of capital in other developing countries (Pakistan, for example) suggest that the private before-tax rate of return on physical capital in the industrial sector is on the order of 30 percent (Guisinger, Henderson, and Scully 1984). If opportunity costs of this magnitude were netted out from the gross returns to schooling in rural Egypt, the private net returns to the typical year of schooling for income and wage earners would become negative.

Columns (2) and (4) of Table 40 present the results of the model when the schooling variable is estimated as a set of dummy variables. In both equations the EX and $EX^2$ variables are significant and of the expected sign. For income earners, three of the four schooling dummy variables (SCH2, 3, and 5) are statistically significant. For wage earners, two of the four schooling dummy variables (SCH3 and 5) are significant.[60]

Private rates of return to education, based on the level achieved, can be calculated from the data in Table 40 by taking the difference between the schooling dummy variables for each interval and then dividing by the difference in years of schooling completed between each interval (Psacharopoulos 1981). Such a procedure is complicated in this data set by the absence of any recorded number for the years of completed schooling for those in the SCH2 interval (less than 6 years of schooling). For this interval, the years of completed schooling were therefore estimated at 2.0.

For income earners, annual private rates of return range from a low of -5.7 percent for elementary/preparatory graduates to a high of 7.3 percent for high school graduates (Table 41). For wage earners, private rates of return range from -4.7 percent for elementary/preparatory graduates to 10.6 percent for high school graduates.

It is surprising to note that for both sets of earners in Table 41 annual private rates of return for elementary/preparatory graduates are *negative*. There are two possible explanations for this unusual outcome. First, as shown in Table 39 (columns 2 and 4), this may be caused by a small-numbers problem. For both sets of earners the numbers of elementary/preparatory graduates are limited. Second, since no guarantees of government jobs are extended to elementary/preparatory school graduates, a process of negative selectivity may be operating here. This means that the negative rates of return

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[60] When equation (30) is corrected by Heckman's procedure, schooling variable SCH5 (university graduate) changes both sign and significance: it becomes negative and statistically insignificant. The standard error for this variable in Heckman's correction is four times more than it is in the uncorrected equation. This is indicative of multicollinearity on SCH5.

Table 41—Annual private rates of return to education, 1986/87

| Educational Level | Income Earners[a] | Wage Earners[b] |
|---|---|---|
| | (percent) | |
| Less than six years schooling | 3.36 | -3.51 |
| Elementary and preparatory school | -5.70 | -4.74 |
| High school | 7.34 | 10.59 |
| University | 5.27 | 5.53 |

Notes: Rates of return are calculated from schooling dummy variables in equation (30) of the text. N = 1,501 income earners and N = 577 wage earners.

[a] Income-earners include all those employed as farmer/peasants and merchants.

[b] Wage earners include all those employed as agricultural laborers, government workers, artisans, private-sector workers, or professionals.

to elementary/preparatory school may be caused by the fact that only the least gifted of graduates choose to leave school at this level.

It is also interesting to note in Table 41 that annual private rates of return for *all* levels of schooling in rural Egypt are considerably below those recorded in other developing countries. In a review of 16 developing countries, Psacharopoulos (1981) found that annual private rates of return to primary education averaged 26.5 percent. In the same review Psacharopoulos found that annual private rates of return to high school education in 14 developing countries averaged 19.2 percent. All of the private rates of return recorded here are far below those cited by Psacharopoulos.

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# INCENTIVES AND CONSTRAINTS IN THE TRANSFORMATION OF PUNJAB AGRICULTURE

Anya McGuirk
Yair Mundlak

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# INCENTIVES AND CONSTRAINTS IN THE TRANSFORMATION OF PUNJAB AGRICULTURE

**Anya McGuirk**
**Yair Mundlak**

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# FOREWORD

The introduction of modern crop varieties in the mid-1960s caused a dramatic change, known as the "green revolution," in agricultural production in Asia, as elsewhere. However, in spite of their higher yields, the process of adoption of these varieties has taken a long time, and even today traditional varieties are still widely grown. Various reasons, such as imperfect information, uncertainty, inadequate human capital, and institutional constraints, have been given for this slow diffusion. This research report by Anya McGuirk and Yair Mundlak on the Indian Punjab experience during 1960-79 emphasizes the role of economic incentives and resource availability in determining the pace of technology adoption.

Only three years after their introduction, the modern wheat varieties accounted for 70 percent of the wheat area in Punjab. Thereafter, their spread was more gradual. From this pattern, the authors conclude that the main determinant of the pace of adoption could not have been uncertainty or lack of information. The modern varieties perform best under irrigation and heavy doses of fertilizer, and therefore their expansion was constrained by the availability of irrigated area and fertilizers. The expansion of these inputs required mobilization of resources from other activities. The improvement in yields increased the rate of returns to investment in irrigation and fertilizer production and thus generated a gradual expansion in their supply. Since total resources are scarce, such a shift is time-consuming.

This explanation illustrates what the authors see as a general and important aspect of the implementation of new technology. When the resource requirements of the new technology are different from those of the existing technology, the pace of implementation will be determined by the speed at which the resources can be shifted to the new technology. This speed depends on the difference in productivity between the new and existing techniques and on prices and overall resource availability. This identification of the process has far-reaching implications for policies directed toward agricultural growth.

This study is part of IFPRI's continuing research efforts in analyzing the nature and economic consequences of technological change and follows earlier work on the green revolution.

Just Faaland

Washington, D.C.
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Anya McGuirk
Yair Mundlak

# 1

# SUMMARY

Much of the rapid growth in output experienced by Punjab, India, during the period of this study was generated by agricultural growth. Most of this agricultural growth is attributed to growth in crop production resulting from improvements in the overall yields of wheat and rice and, to a lesser extent, in the yields of maize and cotton. The pattern of growth in overall yields for the various crops, particularly wheat and rice, suggests that the main improvements came as a result of a shift to modern higher-yielding varieties rather than as a result of intensifying cultivation of the existing varieties.

The extremely rapid adoption of the modern varieties (MVs) of wheat and also rice, once suitable rice varieties were introduced, indicates that factors usually associated with a slow rate of implementation of new techniques, such as imperfect information, uncertainty, institutional constraints, and inadequate human capital, did not appear to play a prominent role in the adoption process. These factors could not have changed much over the extremely short transition period and therefore could not have influenced the rate of adoption. Alternatively, the speed at which the new varieties were implemented, particularly MV wheat, suggests that the pace of transition was largely determined by the productivity of the MVs relative to the traditional varieties and by physical constraints such as, initially, the availability of seeds and, later, the availability of irrigation facilities and fertilizers. Thus, physical capital played a crucial role in the growth process.

The conceptual framework used to model the growth in Punjab agriculture is that of choice of technique. Given that much of the agricultural growth can be attributed to the implementation of new techniques of production, an understanding of the growth process requires that the factors affecting the decision to implement these techniques be identified explicitly. Analyses that aggregate techniques by crop potentially provide distorted views of the technology and therefore of the growth process. Thus, the results of this study not only have important policy implications for agricultural growth but also provide evidence of the usefulness of the choice-of-technique approach.

The techniques of production analyzed are those of the major crops in Punjab, identified by variety, season of growth, and method of production (irrigated or dry). The short-run area-allocation decisions are influenced by the expected revenues of the different techniques; the availability of fertilizers, irrigation, and cropped area; and the local environment. Overall yields by crop are determined by the composition of techniques implemented, the availability of fertilizers, and the local physical environment.

Because resources are scarce and therefore have to be attracted to agriculture from other uses, changes in the availability of fertilizers, irrigation, and cropped area are determined by the overall availability of resources and the differential rate of return between agriculture and nonagriculture. The relative importance of these factors depends on whether the decisions are made by the public or private sector.

Equations analyzing the investment decisions of both the private and public sectors are estimated simultaneously with the area allocation and yield equations. The data base utilized in this study consists of district-level observations over the period 1960 through 1979. The effects of the local physical environment, the initial levels of infrastructure, and the availability of human capital on choice of technique and overall level of output are detected by the inclusion of fixed district effects.

The results are summarized by deriving both short-run and long-run elasticities. The specification of the model implies that the size of both the short-run and long-run elasticities depends on the productivity of the implemented technology; the more productive the implemented technology, the greater are the elasticities (in absolute value).

The short-run output elasticities with respect to price are generally small, as the constraints are binding. The short-run aggregate output elasticity with respect to a change in all (real) prices increased from nearly zero before the onset of the "green revolution" to a high of 0.18 in 1979, when the transition to MVs of wheat and rice was largely complete. Thus, conditional on the availability of quasi-fixed inputs, total output responds little to changes in price.

The short-run elasticities of output with respect to the constraints indicate that the availability of quasi-fixed inputs played a major role in the determination of the pace of transition to MVs. The magnitude of these elasticities is large relative to their price counterparts. The availability of private irrigation and roads appears to have been particularly important in the transition process.

The results from the quasi-fixed input equations suggest that the decisions made by farmers about irrigation, and indirectly about net cropped area, were responsive to the increase in profitability spurred by the introduction of MVs. The long-run elasticities of area irrigated by private resources with respect to prices and the availability of roads and fertilizers were particularly large.

Although similar responses were not obtained in the government investment equations as specified, the observed increases in the provision of electricity and the availability of fertilizers and roads suggest that the government responded to the new opportunities.

The long-run output elasticities with respect to prices are all large relative to their short-run counterparts. These elasticities reflect the strong response of private irrigation and the somewhat more moderate response of net cropped area and fertilizers as the prices changed. The long-run aggregate supply elasticity, although negligible before the onset of the green revolution, reached a high between 1.3 and 1.5 in the late 1970s.

# 2

# INTRODUCTION

On the whole, economic growth is driven by technical change. Therefore, an understanding of the many factors that influence technical change is key to an understanding of economic growth and the potential for that growth. The introduction of technical change has two aspects: first, it has to be generated, and second, it has to be implemented. This manuscript deals with the implementation of new techniques of production. In particular, the focus of this study is on the determinants of the level and rate of implementation of the modern wheat and rice varieties (MVs) as well as new varieties of cotton and maize introduced in Punjab, India, during what is now commonly referred to as the green revolution. The pattern of crop production growth experienced by Punjab over the period of study, 1960-79, suggests that much of this growth came as a result of the implementation of these new techniques. Further, it is the dramatic growth in crop production that is largely responsible for the rapid growth in net domestic product (NDP) experienced by Punjab.

Once a new technique of production becomes available, it usually takes some time before it is fully implemented. The transition period is characterized by coexistence of the traditional and modern techniques. Various explanations for such a transition period are provided in the literature. Some see it as a diffusion process (for example, Desai 1982). But this is not an explanation; it is merely another way to say that the process takes time. Other explanations are given in terms of the existence of imperfect information that is naturally associated with a new technique. However, when a new technique is considerably superior to the existing ones, as in the case of the MVs of wheat and rice introduced in Punjab, farmers are able to realize the gain quickly, without a long search for information. In this case, the producers' search for information cannot, by itself, explain the existence of a transition period. Furthermore, a delay in adoption due to such searching would suggest that adoption of the new techniques will initially be slow and will then pick up momentum as information on the quality of the new technique is accumulated. This type of adoption pattern is opposite to the one observed for the MVs of wheat and rice in Punjab. For example, the first year the MVs of wheat were introduced, they were sown to 30 percent of the total wheat area. This proportion had increased to 70 percent by only the third year. The experience with rice was similar, once a suitable variety was introduced. As the opportunity to adopt the more productive techniques arose, farmers implemented them rapidly.

Another explanation of the existence and pace of the transition process, which is related to the last, is scarcity of human capital. There is no question that human capital is necessary in the generation of new techniques and also in their implementation. However, it is impossible to generalize about the role of human capital in the implementation of the new techniques because it depends on the nature of the innovation. Some innovations may actually reduce the demand for some forms of human capital and so can be considered as saving human capital. Others may require only a small increase in some specific human capital that may be acquired in a short time period, building on the existing knowledge. In such cases, human capital may not be a serious constraint. This is believed to be the case for Punjab, which, given the rapid adoption of MVs, appeared to have the necessary human capital to make the transition. Because the availability of human capital could not have changed significantly over the extremely rapid transition period, changes in human capital could not have had a major effect on the pace of adoption.

What, then, were the main constraints that determined the pace of the transition to MVs in Punjab? Clearly, the MVs of wheat and rice introduced in Punjab were much more productive than the traditional varieties. However, to fully utilize their yield potential, it is necessary to apply considerably larger doses of fertilizers and water per unit of land in comparison with the quantities used for the traditional varieties. Consequently, an increase in the area planted to MVs required an expansion in the supply of fertilizers and irrigation facilities as well as an expansion in complementary inputs, such as electricity, for the operation of wells and roads needed to integrate the remote areas within the market. The speed at which the new varieties of wheat and rice were implemented suggests that the pace of transition was largely determined by the productivity of the MVs relative to the traditional varieties and the availability of physical capital.

The conceptual framework used to examine this working hypothesis is that of choice of technique, where the choice is analyzed explicitly. In other studies—Cavallo and Mundlak 1982, Coeymans and Mundlak 1987, and Mundlak, Cavallo, and Domenech 1989—this framework was applied to macro data where output is aggregated over all techniques without identifying the individual techniques. Consequently, the effect of the various determinants of the choice of technique is revealed empirically only in an implicit way. One important attribute of this study is that techniques are identified by crop variety, season of growth (*rabi* and *kharif*), and method of production (dry versus irrigated). Data on area allocated to these varieties are available and serve as a measure of their degree of implementation. It is therefore possible to measure the effect of the determinants of technique choice directly and explicitly. Thus the results of this study have broad implications for the usefulness of the choice-of-technique approach in empirical analysis as well as for policy aimed at influencing agricultural growth.

The data base for the study consists of district-level observations over the period 1960-79. The techniques of production analyzed are those of the major crops grown in the Punjab. The production decisions are formulated by assuming that, in the short-run, farmers simultaneously allocate their resources between the various techniques (intertechnique allocation) and decide on the level of intensity of technique implementation (intratechnique allocation) to maximize their value added from production. These decisions are made subject to the following constraints: cropped area, irrigation capacity by source (private tubewells and government canals), and fertilizer availability. Economic performance and, therefore, decisions are also influenced by the availability of infrastructure, such as roads, and by the local physical environment. Consequently, the area-allocation decision is a function of prices, constraints, environmental factors, and available technology. The coefficients on the price variables are allowed to depend on the implemented technology, thus average revenues per hectare are used as the measure of incentives. The premise is that a shift to the new, more-productive technique generates higher returns to land when compared with the existing varieties, so a given change in prices will have a stronger effect on area allocated to the more productive variety than to the traditional lower-yielding variety.

The yields of the various crops are determined by the composition of techniques used in planting and by the intensity of their implementation. Although the inter- and intratechnique decisions are made jointly at the beginning of the growing season, because production takes time and information sets change, the actual application of inputs during the production season may differ from the levels initially chosen. The yield equations take all these factors into account. Total crop output is determined as a product of area and yield and, as such, is affected by all the state variables that affect these two components individually.

Changes in the constraints require investment. As resources are scarce, they have to be attracted from other sectors. A distinction is made between investment decisions taken privately by farmers and those taken by the government. It is postulated that the private sector chooses levels of investment that maximize the present value of the future stream of value added. As technical change occurs, the flow of value added increases and investment becomes more profitable. Therefore, agriculture's share in total investment should increase. The government's decision to invest is more complicated and is not captured in this study. However, the government also mobilized resources as the profitability of agriculture increased. The supply of fertilizers, electricity, roads, and to a lesser extent, public irrigation all increased over the period of study.

Background information on Punjab is provided in Chapter 3, discussing in detail the growth in Punjab agriculture during 1960-79. Chapter 4 outlines the conceptual framework that is used as the point of departure for this study. Chapter 5 is devoted to the empirical results of the short-run area-allocation and yield responses conditional on the constraints or quasi-fixed inputs. Based on these results, a comprehensive and consistent picture of the transition of Punjab agriculture is detailed. Chapter 6 discusses the changes in the availability of the quasi-fixed inputs in response to the changing profitability of crop production and the long-run elasticities. Finally, conclusions are drawn in Chapter 7. See Appendixes 1 and 2 for detailed discussions of the major data issues.

# 3

# AN OVERVIEW OF AGRICULTURAL DEVELOPMENT IN PUNJAB

A summary description of the development in Punjab agriculture is provided to assist in placing the subsequent analysis in an appropriate perspective. Because much has been written about Punjab elsewhere, only a brief discussion of the relevant background and historical information is provided.[1] The primary focus of the summary is the performance of present-day Punjab during the period of study (1960-79).

## Background Information

Punjab is the fourth smallest state of India, accounting for approximately 1.6 percent of the total area (Mehra 1983). According to the 1981 census (India 1981a, 1981b), 17.7 million people, or 2.4 percent of the Indian population, live in Punjab. Punjab is largely a rural state; 72 percent of the population live in rural areas. Since its annexation by the British in 1849, the former Punjab has undergone several geographical changes, the most significant being the partition in 1947. The many internal and external boundary changes make it difficult to assess the growth record of present-day Punjab. This is particularly true for analyses at the district level, because most district-level data have not been adjusted for these changes. Appropriate adjustments have been made to the published data for the analysis and discussion of the performance at the district level.[2]

## Sectoral Output

By many conventional measures, Punjab is well advanced relative to much of the rest of India.[3] In 1981, per capita NDP in Punjab was 1.8 times that of all India and 3.2 times that of Bihar, the poorest state in the country. Of all Indian states, Punjab has the lowest percentage of people below the poverty line, and it has the highest average life expectancy.

During the 1960s and 1970s, the real NDP of Punjab grew at a compound rate of 4.9 percent a year (Figure 1). This growth was largely generated by the growth

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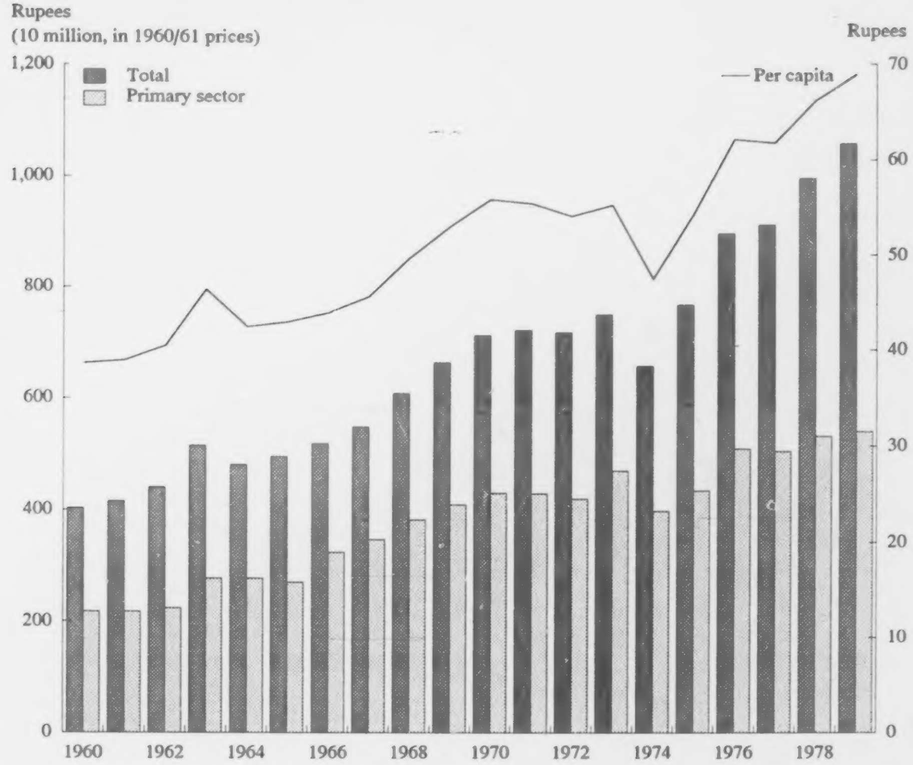
[1] In addition to the specific references cited throughout this chapter, other important references on Punjab include Sims 1988, Chaudhri 1979, Bhalla et al. 1990.

[2] The adjustments made to the district-level data are detailed in Appendix 1. A "consistent" series has been constructed using data from 11 out of the 12 districts of present-day Punjab.

[3] This section draws on Westley 1986 and Singh 1983.

Figure 1 — Net domestic product, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

of agriculture. Value added by the primary sector, which is largely agriculture, grew at a rate of 4.4 percent annually between 1960 and 1980. This performance is impressive when compared with that of all India and of other countries (Table 1). It is more than double that of India, almost twice that of low-income countries (excluding China and India), and significantly greater than that of the middle-income countries. Agricultural growth has induced growth in the economy at large, with the secondary sector (industry) growing at a 6.2 percent annual rate over 1960-79, and more strikingly, at a 16 percent rate during the last five years of the 1970s. The annual growth rate of the tertiary sector (services) during these two recent decades was 4.7 percent, but between 1975 and 1979 the sector grew at a spectacular rate of 36 percent a year.[4] The differences in growth rates by sector

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[4] Because a complete time series of value added was not provided in Westley 1986 (Table 1), real NDP (Figure 1) is used to summarize the performance of the various sectors over different periods within this sample.

**Table 1—Average annual real growth rate in value added, by sector, 1960-80**

| Sector | Punjab | India | Low-Income Countries | Middle-Income Countries |
|---|---|---|---|---|
| | | (percent) | | |
| Primary | 4.4 | 1.9 | 2.3 | 3.1 |
| Secondary | 7.0 | 4.5 | 5.1 | 7.2 |
| (Manufacturing)[a] | (7.5) | (4.7) | (5.0) | (6.0) |
| Tertiary | 5.6 | 5.0 | 4.4 | 5.7 |

Source: Based on data from John R. Westley, *Agriculture and Equitable Growth: The Case of Punjab-Haryana* (Boulder, Colo., U.S.A.: Westview, 1986).

[a] Manufacturing is a part of the secondary sector and is therefore shown in parentheses.

largely reflect differences in income elasticities and the relative importance of the various sectors. The sectoral composition of Punjab's economy in 1980 is presented in Table 2.

## Importance of Agriculture

Agriculture is the single most important component of the primary sector. In 1980 it accounted for 73 percent of the NDP of the primary sector, and according to the 1981 census, nearly 60 percent of Punjab's total labor force is employed in agriculture. This is slightly higher than the 56 percent figure reported in 1961, but lower than the 63 percent for 1971.

Over the two decades under discussion, crop production has continued to dominate agriculture. However, its growth rate lagged behind that of livestock, which increased its share in agriculture's NDP from 13 percent in 1960 to about 29 percent in 1980. Again the differential growth rate can be attributed to a higher income elasticity for livestock products, which fits the picture of overall growth. However, it remains true that much of the success of Punjab agriculture can be attributed to the expansion in crop production that accompanied the adoption of MVs during the period of time now commonly referred to as the green revolution.

**Table 2—Sectoral shares in value added, 1980**

| Sector | Punjab | India | Low-Income Countries | Middle-Income Countries |
|---|---|---|---|---|
| | | (percent) | | |
| Primary | 50 | 38 | 45 | 15 |
| Secondary | 21 | 25 | 17 | 37 |
| (Manufacturing)[a] | (13) | (17) | (10) | (23) |
| Tertiary | 29 | 37 | 38 | 48 |

Source: Based on data from John R. Westley, *Agriculture and Equitable Growth: The Case of Punjab-Haryana* (Boulder, Colo., U.S.A.: Westview, 1986).

[a] Manufacturing is a part of the secondary sector and is therefore shown in parentheses.

## Trends in Crop Production

Crop production across Punjab is diverse, but for the period under study, the five major crops analyzed here (American and Desi cotton, wheat, rice, maize, and gram) accounted for 67-80 percent of the gross cropped area.[5] During 1960-80, the cultivated area for these crops in Punjab increased only from 4.5 million to 4.6 million hectares, while real value (in 1960/61 rupees) of production rose from Rs 1,253 million to Rs 3,996 million. This translates into an annual growth rate in the real value of production per hectare of 4 percent over the 20-year period.

Agricultural output depends on (among other factors) the physical environment, which includes factors such as soil quality and climate. For descriptive purposes, Punjab can be divided into three geographical regions: the northern submontane (hilly) strip, the central plains, and the southwestern region (Figure 2). The submontane strip in the north contains major portions of the districts of Gurdaspur, Hoshiarpur, and Rupnagar. Maize and wheat tend to be the major crops in the hilly region, although significant amounts of gram, *bajra* (pearl millet), rice, mustard, lentils, and potatoes are also grown (Mehra 1983). Despite an average annual rainfall for this area of about 87 centimeters, agricultural productivity of the submontane strip is low relative to that of the other two regions in Punjab (Bhalla and Khan 1979).

The central plains comprise the districts of Amritsar, Kapurthala, Jullundur, Ludhiana, and Patiala, and most of Sangrur. High-value crops such as wheat and gram are grown during the winter, and rice, maize, cotton, sugarcane, and pulses are grown during the summer. The average annual rainfall for the region is 57 centimeters, of which 46 centimeters are received during the summer monsoons (Bhalla and Khan 1979). The alluvial soils along with the given rainfall make this region the most productive in Punjab.

The southwestern region contains the districts of Ferozepore, Bhatinda, Faridkot, and part of Sangrur.[6] The average annual rainfall in the area is a meager 27 centimeters, of which 23 are received during the monsoons. Wheat, gram, and cotton are grown in the irrigated parts of this region; *jowar* (sorghum), *bajra,* and rapeseed/mustard are grown in the less-irrigated parts (Mehra 1983).

The climatic conditions of Punjab allow the possibility of double cropping. The two main harvests are the *rabi* or spring harvest and the *kharif* or autumn harvest. *Rabi* season crops are sown in October and November after the monsoons and harvested from mid-March to mid-May. The main *rabi* crops include wheat and gram as well as barley and green fodder. *Kharif* season crops are sown from June to August and harvested from early September to late December. The main *kharif* crops include rice, maize, *bajra,* and *jowar.* Cotton is also considered a *kharif* crop,

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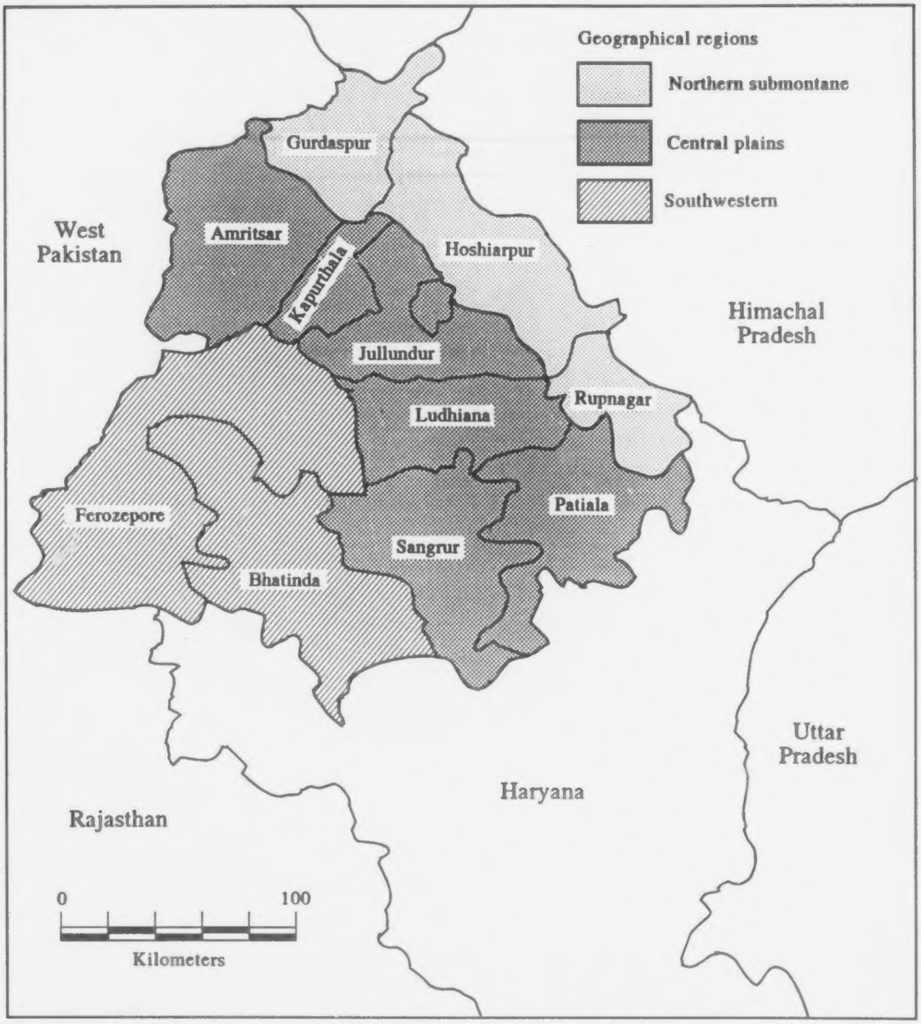
[5] The data include production in 11 of Punjab's 12 districts, although data from Faridkot are included along with Bhatinda and Ferozepore (see Appendix 1).

[6] The present-day district of Faridkot is included within Ferozepore and Bhatinda (see Appendix 1). Even though part of Sangrur lies in the southwestern region, all of Sangrur is shaded in the map (Figure 2) because the exact boundaries are unknown to the authors.

**Figure 2—Map of the districts of Punjab**



although it is sown earlier than most other *kharif* crops. Similarly, sugarcane is considered a *kharif* crop, although it is sown from February to April and harvested between December and March.

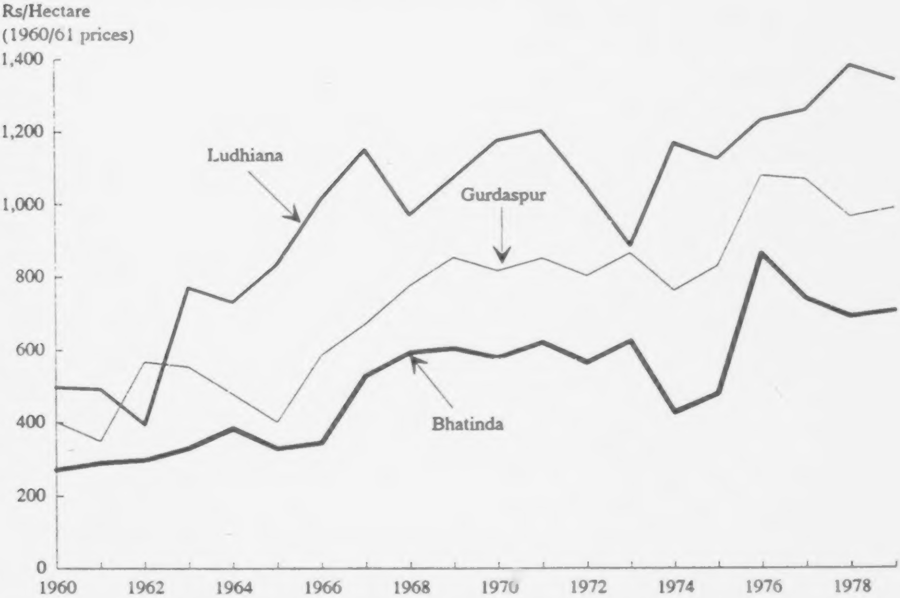
Because the physical environment does not change very rapidly over time, its main effect on output can be detected from cross-section comparisons. In the present study, this is done by analyzing district data.

To provide some perspective on the differential performance by districts, values of production per hectare for Ludhiana, Bhatinda, and Gurdaspur are illustrated in Figure 3. These districts are used throughout the discussion to demonstrate the variability in performance across the state. They were chosen because each is located in one of the three distinct geographical regions of Punjab described above.

Value of production per hectare increased in all three districts during 1960-80, and on the whole, the same performance rank was sustained across the three districts. However, performance varied considerably among the districts. In 1960, for example, the value of production per hectare in Ludhiana was 19 percent higher than in Gurdaspur. In 1966, this differential rose to 42 percent but moderated to 24 percent by 1980.

Growth has also varied by crop, largely due to the adoption of MVs. The yields of wheat and rice in Punjab increased 124 and 175 percent, respectively, during 1960-79.[7] However, the time pattern of this growth varied by crop. Growth in wheat yields outperformed rice yields by a margin of 18 percent during the 1960s, while rice yields increased 42 percent more than wheat yields in the 1970s. In

Figure 3— Value of production per hectare in three districts, 1960-79



Sources: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years); and India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

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[7] To assess the improvement in yields over the sample period, the average yield during 1960-62 is compared with the 1977-79 average yield.

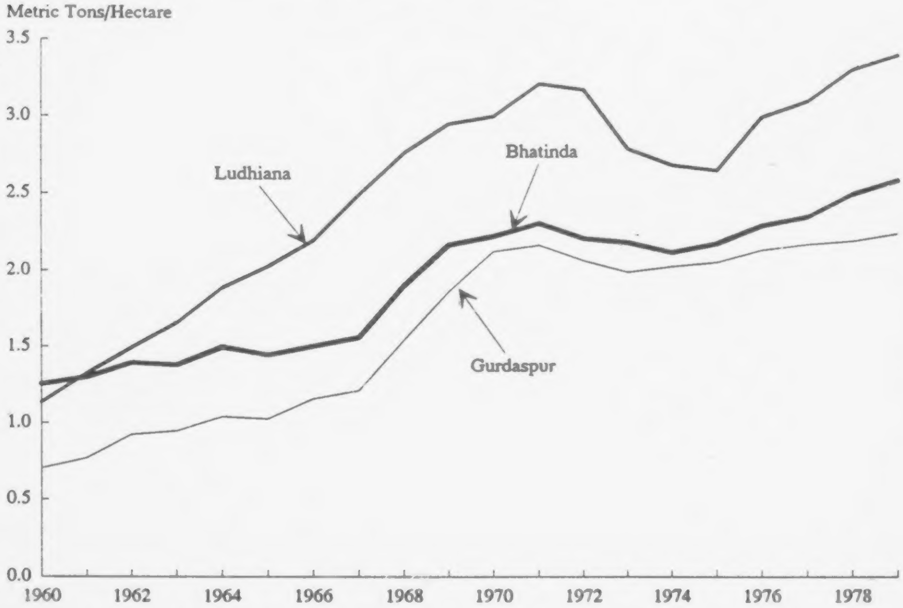
contrast to the spectacular performance of the rice and wheat yields, the yields of both gram and Desi cotton showed no improvement over the sample period. Maize and American cotton yields increased 46 and 30 percent, respectively, but a good part of this improvement occurred prior to the onset of the green revolution.

Figures 4 through 9 illustrate the changes in yields for these crops by district. For the three districts, there were substantial increases in yields of rice and wheat, and, in one district, American cotton. Ludhiana obtained the highest yields in wheat and maize; the yields of cotton and rice were particularly low in Gurdaspur and relatively high in Bhatinda.

## Introduction of the Modern Varieties

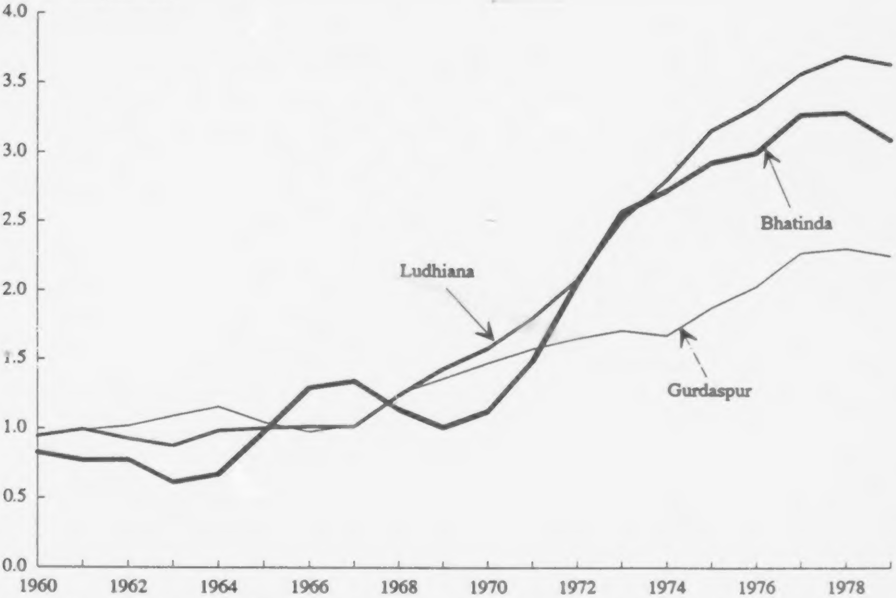
According to Mohan, Jha, and Evenson (1973), Punjab (and Haryana) consistently invested more heavily in agricultural research over the 1953-68 period than any other state in India. In 1968, research expenditures per community block were 25 percent higher in Punjab than in Haryana, which was second in spending, and 75 percent higher than in Gujarat, which was third. Although Mohan, Jha, and

Figure 4 —Wheat yield in three districts, 1960-79



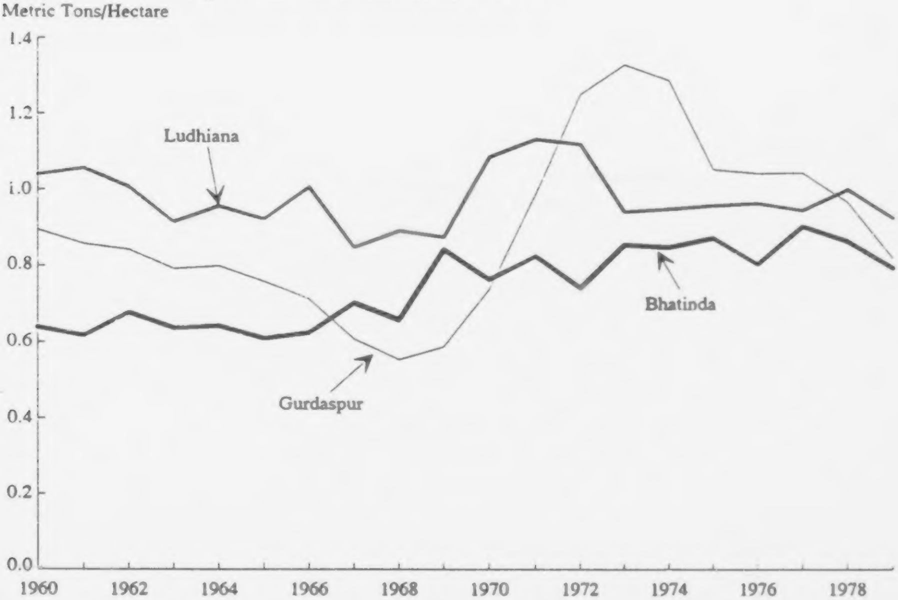
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 5 — Rice yield in three districts, 1960-79



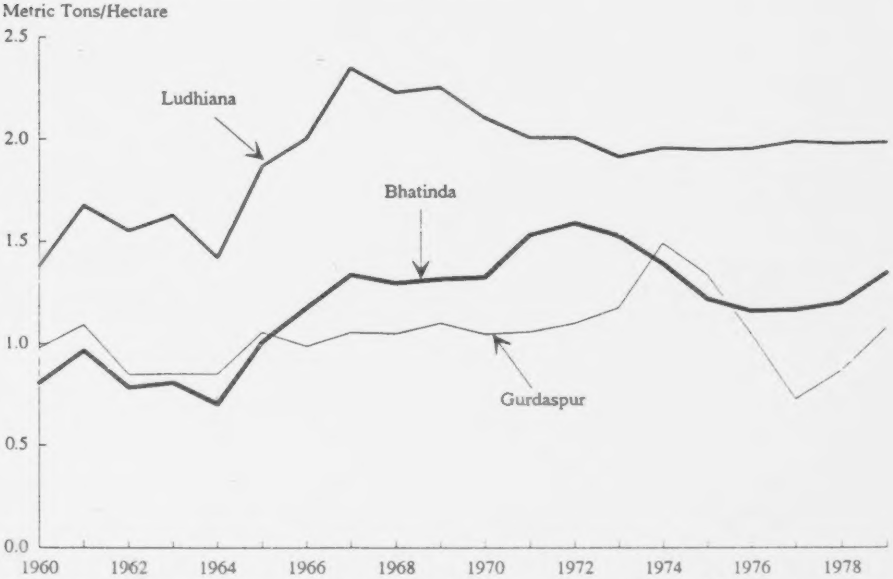
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 6 — Gram yield in three districts, 1960-79



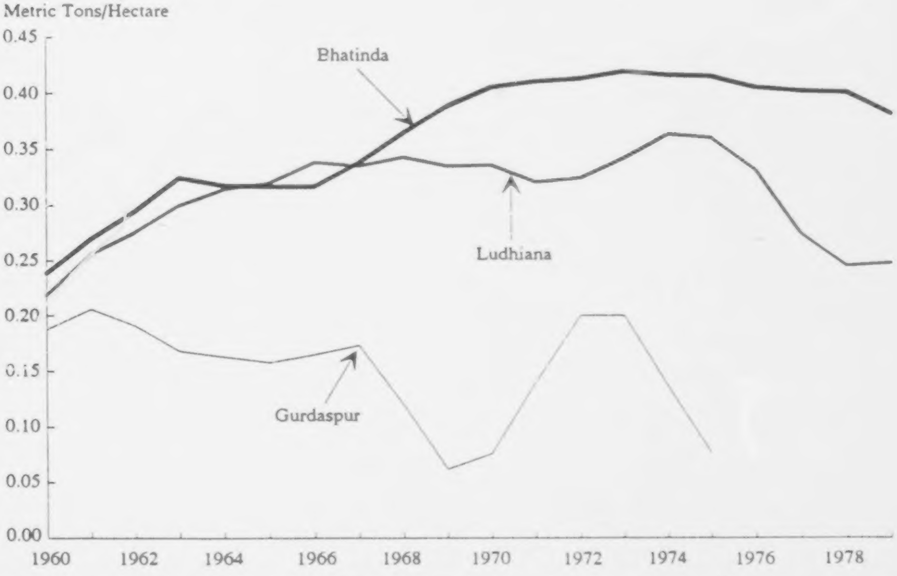
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

## Figure 7 — Maize yield in three districts, 1960-79



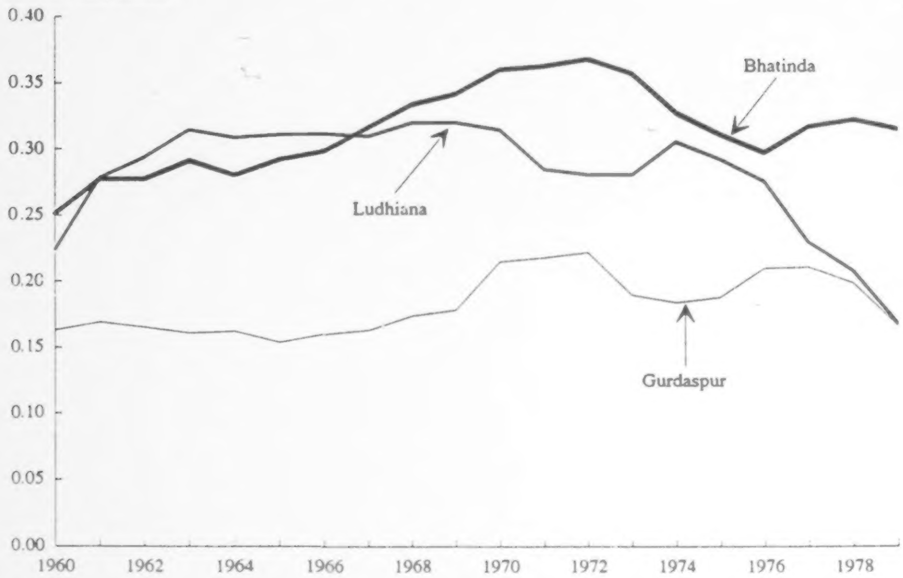
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

## Figure 8 — American cotton yield in three districts, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 9 — Desi cotton yield in three districts, 1960-79



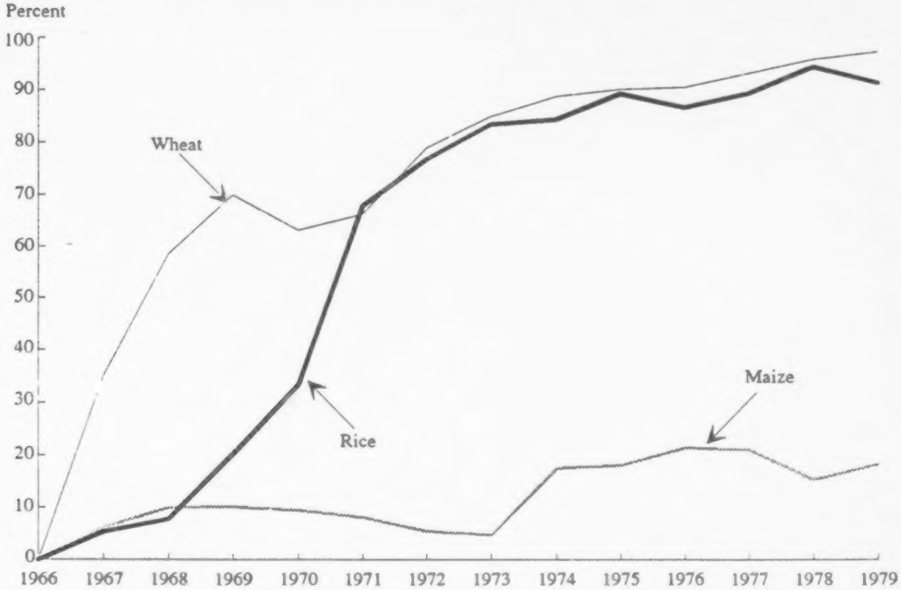
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Evenson did not relate research expenditure to economic performance by the state, the payoff on this investment in research seems evident from the performance of the Punjab Agricultural University, which played a key role in the development of new crop varieties.

For the most part, the changes in crop yields described above are attributed to the introduction of MVs. Mexican dwarf wheat varieties were first tested at the Punjab Agricultural University in 1964. Seed multiplication and production followed in 1966, and by 1968 the MVs for rice, maize, and *bajra* had also been released. Since then, the initial MVs have been continually modified to meet demand. For example, problems of acceptance by consumers were overcome by the replacement of the PV-18 variety of wheat, which had a small reddish grain, with the amber-colored grain of the Kalyan Sona variety. As another example, in 1972 the timing constraint that limited double cropping of the MVs of wheat and rice was overcome by the release of a new variety of rice that matured in four months.

The average adoption levels of the MVs of wheat, rice, and maize are presented in Figure 10. It is important to note that the adoption of MV wheat was extremely rapid, with over one-third of the area planted to wheat being sown to the new varieties in the first year of availability, and by 1969/70, only three years later, this rate had increased to about 70 percent. This indicates that factors that are often

Figure 10 — Proportion of area sown to modern varieties in Punjab, 1966-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

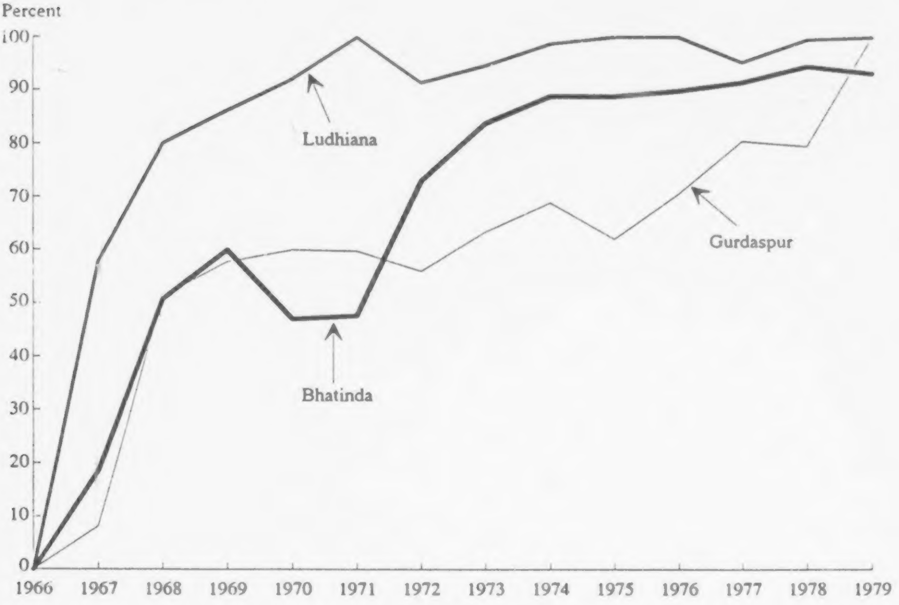
thought to slow down the pace of adoption of new varieties, such as lack of information, uncertainty, or institutional constraints, did not play an important role in the case of wheat. On the other hand, the rate of adoption slowed down after the first three years, which indicates that eventually the progress was hindered by constraints that were gradually removed. This subject will be dealt with in detail in the subsequent chapters.

Adoption of MV rice, on the other hand, was initially slow; by 1969/70 only 20 percent of the area sown to rice was planted in MV rice. To some extent this slow start can be attributed to the infeasibility of the wheat-rice rotation during the first years of the green revolution. However, by the early 1970s, adoption rates of MV rice soared, and by 1971/72, adoption rates of MV rice matched those of MV wheat.

Adoption of MV maize followed a completely different pattern. It was extremely slow and leveled off just below 20 percent in 1979. The lack of acceptance of the MV maize varieties is largely attributed to their poor resistance to disease and drought (Johar and Raikhy 1983). Again, this does not reflect lack of information as a constraint to adoption, but just the opposite.

The rates of adoption varied by districts. Figures 11 and 12 illustrate the acceptance rate of these varieties of wheat and rice in the districts of Bhatinda,

**Figure 11—Proportion of wheat area sown to modern varieties in three districts, 1966-79**



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Ludhiana, and Gurdaspur. Although there has been near complete adoption of wheat in these districts, the adoption of rice is still less than complete. This is particularly evident in Gurdaspur, where, 15 years after the onset of the green revolution, over 25 percent of the area planted to rice is still sown to traditional varieties. In this area, these may consist largely of the Basmati type, which is of high quality and brings a high price.[8]

Despite the almost complete adoption of MV wheat by the end of the sample period, the adoption paths of the three districts are very different. All three districts experienced rapid acceptance of the new varieties in the first two years following their initial introduction. In the next four years, however, adoption quickly tapered off in both Bhatinda and Gurdaspur but continued with great strength in Ludhiana. By 1971/72 the adoption process was nearly complete in Ludhiana, but was less than 60 percent complete in the other two districts. It was not until 1979/80 that the gap between these districts was eliminated.

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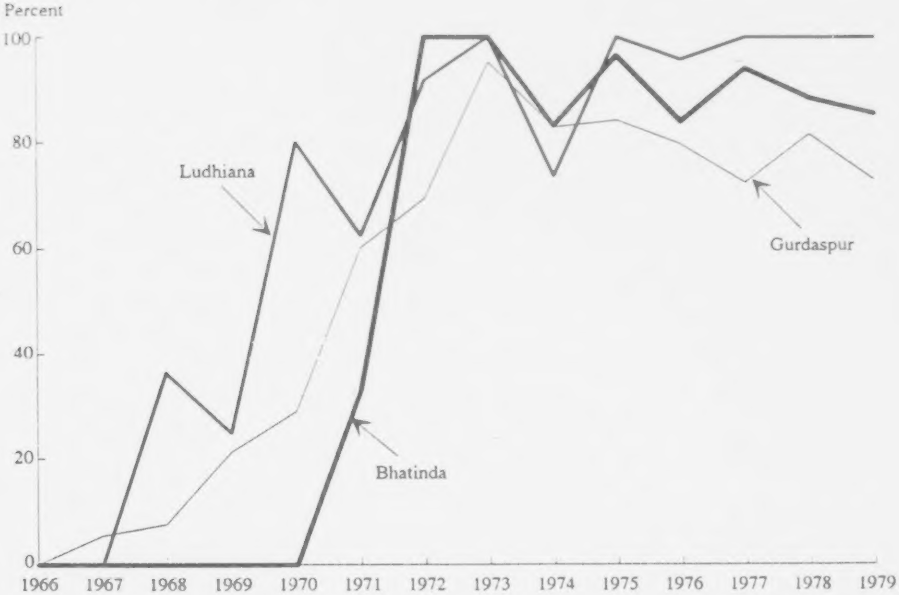
[8] This explanation was suggested to the authors by John Mellor in private correspondence.

Figure 12 — Proportion of rice area sown to modern varieties in three districts, 1966-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Just as in the case of MV wheat, adoption rates of MV rice in Ludhiana were much higher than those in Gurdaspur and Bhatinda during the early years of the green revolution. In fact, MV rice was not adopted in Bhatinda at all until 1970/71. All three districts experienced very rapid expansion in the proportion of area planted to MV rice during the early 1970s, each reaching the 90 percent mark by 1973/74. Since that time, however, adoption levels have tapered off in both Gurdaspur and Bhatinda. The remaining small shares of the traditional varieties in these districts may indicate the existence of ecological niches where the MVs do not fit.

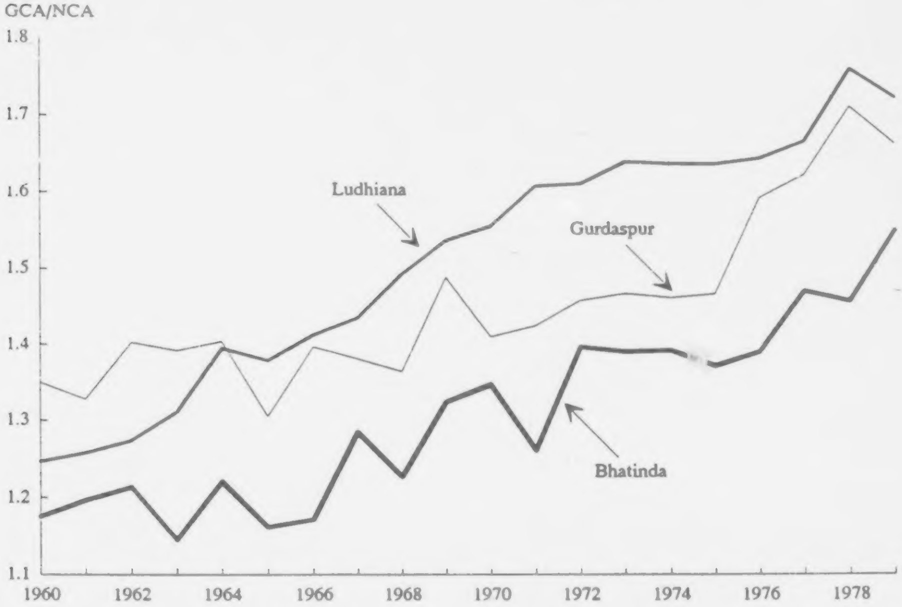
## Land-Use Patterns

Over the period 1965/66-1980/81, the proportion of geographical area in the state being cultivated (net cropped area) increased from 76 to 83 percent, an increase of 414,000 hectares for the 11 districts in this study. In 1980, it was estimated that only 5 percent of the area in Punjab was covered by forests, compared with 22 percent in India as a whole (Chadha 1986). Thus the only hope for further increases in cultivatable area appears to be through reclamation of waterlogged area and area affected by alkalinity and salinity.

The increase in total area sown (gross cropped area) has been far more significant than the increase in net cropped area. Over the sample period, total gross cropped area in Punjab increased by 1.9 million hectares. Consequently, the intensity with which cultivatable area was cropped (gross cropped area/net cropped area) increased from 1.2 to 1.6, indicating a significant increase in double cropping. That is, the amount of land cropped twice in one year increased from 20 to 60 percent of total net cropped area. Figure 13 indicates the intensity with which this area was cropped in the various districts. Cropping intensity increased significantly in all three districts, particularly in Ludhiana.

Similar trends are seen in irrigated area. Between 1960 and 1979, net irrigated area in all 11 districts increased from about 2.0 million to 3.5 million hectares.[9] The growth in net irrigated area for Bhatinda, Ludhiana, and Gurdaspur, measured

Figure 13 — Cropping intensity in three districts, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Note: GCA/NCA (gross cropped area/net cropped area) is the intensity with which cultivatable area is cropped.

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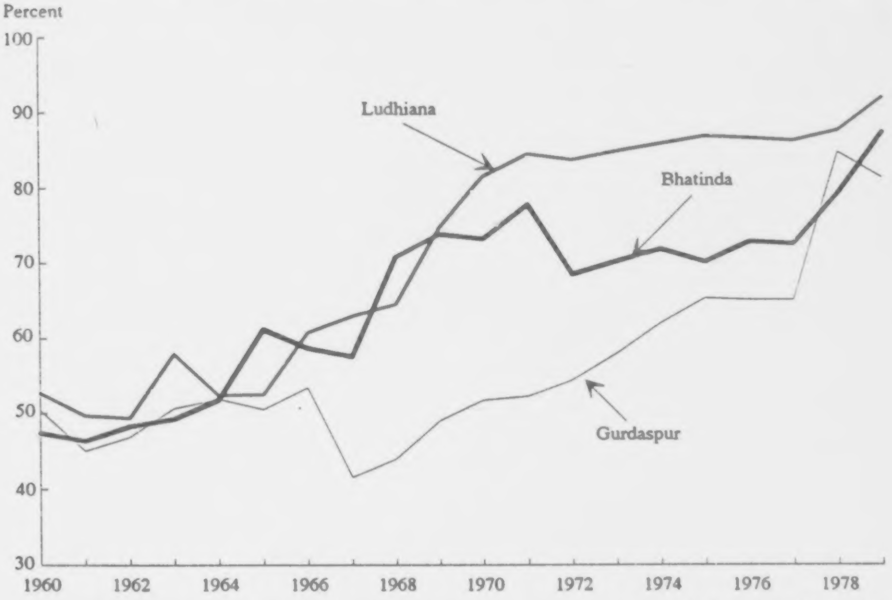
[9] Net irrigated area is the total physical area that can be irrigated, as opposed to gross irrigated area, which is the total irrigated area (includes land that is irrigated in each of the two seasons).

as a proportion of net cropped area, is illustrated in Figure 14. Although the percentage of cultivated area irrigated increased from approximately 50 percent to over 80 percent for those 3 districts, they have followed very different paths from the onset of the green revolution.

Growth in net irrigated area has been accompanied by an even larger increase in gross irrigated area because of an increase in area that is irrigated in both seasons. The intensity with which the net irrigated area in Bhatinda, Ludhiana, and Gurdaspur has been irrigated is illustrated in Figure 15. Although the intensity with which the land has been irrigated has increased, there were sharp variations throughout the sample period. In general, the sharp decreases correspond to years when new land was brought under irrigation.

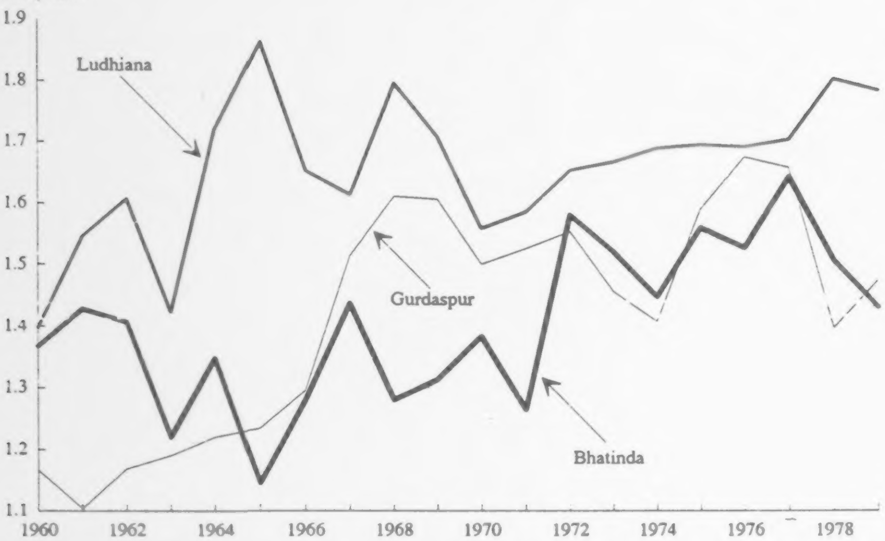
As noted above, there are two distinct growing seasons, *rabi* and *kharif*. The composition of crops grown in these seasons differs, as can be seen in Figures 16-18. Wheat and gram are the main *rabi* crops, and rice, maize, and cotton are the main *kharif* crops. Sugar (included in "other" in the three figures) is the only crop that is in the ground the entire year; all other crops are grown in only one season. As illustrated in Figures 16-18, a much larger proportion of both irrigated and dry land is cropped in the *rabi* season, when wheat has always been the dominant

**Figure 14—Proportion of cultivated area irrigated in three districts, 1960-79**



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

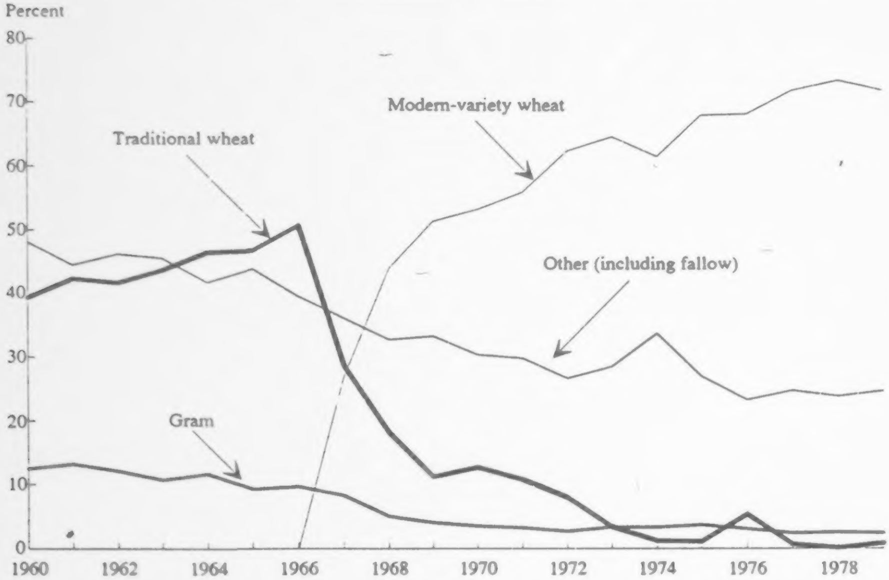
## Figure 15 — Irrigation intensity in three districts, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

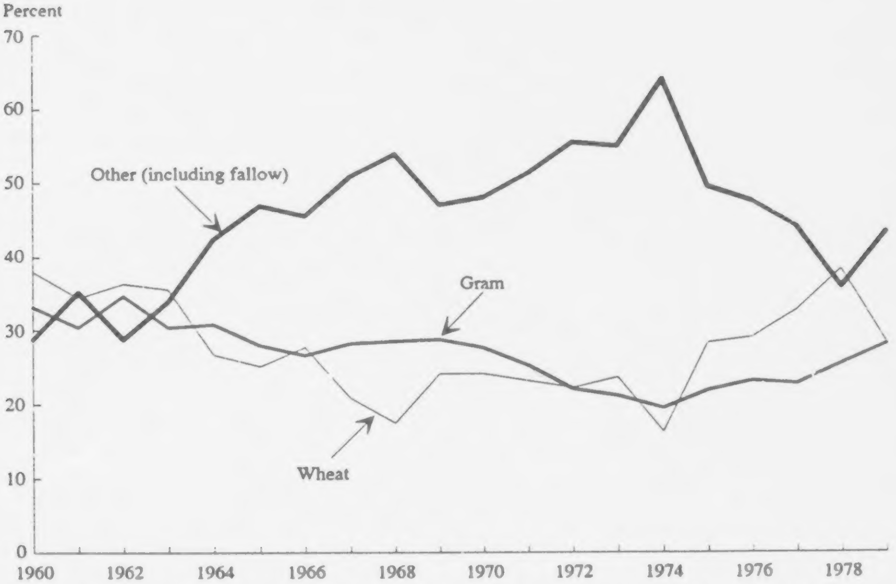
Note: GIA (gross irrigated area) is the total irrigated area, including land that is irrigated in both the *rabi* and *kharif* seasons. NIA (net irrigated area) is the total physical area that can be irrigated.

## Figure 16—Allocation of rabi irrigated area in Punjab, 1960-79



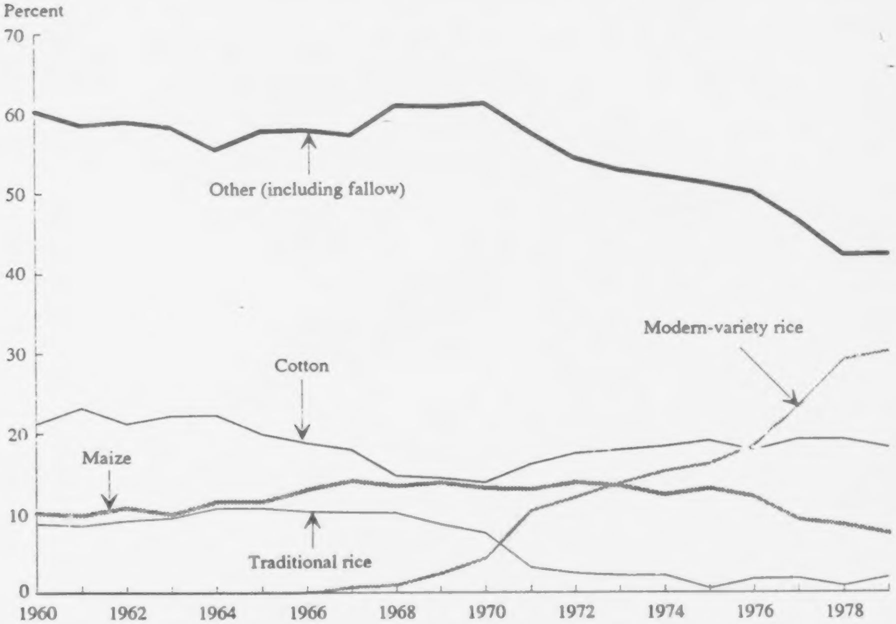
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 17 — Allocation of rabi dry area in Punjab, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 18—Allocation of kharif irrigated area in Punjab, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

crop.[10] Gram has maintained a large share of the dry land during the *rabi* season, but after the onset of the green revolution its share of irrigated land declined significantly. In the *kharif* season, the most obvious change is the large increase in area occupied by rice. Prior to the green revolution, rice occupied less than 10 percent of the irrigated land; by 1979 this had risen to more than 30 percent. Cotton has maintained its share of irrigated land. The share of irrigated land allocated to maize has declined, while its share in dry land has increased slightly. The proportion of dry land cropped in the *kharif* season on the whole is quite small, reflecting the dry conditions of this season. Still, it has increased over the sample period because of changes in the area allocated to both rice and maize.

## Source of Irrigation

Throughout its history, Punjab has been the beneficiary of heavy central and state government investment in canal irrigation systems. As a result of this heavy investment, the proportion of cropped area irrigated in Punjab was greater than any other state prior to the onset of the green revolution. Since that time, Punjab has maintained this lead by bringing even more land under irrigation. It is widely recognized that these changes in availability of irrigation have been critical in the success of the green revolution in Punjab (Gupta and Shangari 1980). In addition, it has been shown that there is a qualitative difference by source of irrigation (Westley 1986).

The increase in irrigated area has been largely due to increased investment in wells. For Punjab as a whole, well irrigation accounted for over 80 percent of the rise in net irrigated area between 1960 and 1979. As a result, the share of land irrigated by wells increased from less than 40 percent in 1960 to more than 55 percent in 1979, and the share of land irrigated by canals declined accordingly (Figure 19). Although the growth in wells was substantial for the state as a whole (Figures 19 and 20), Figure 21 illustrates clearly that the pace of growth varied considerably by district (see discussion below).

The increase in area irrigated by wells has largely been due to an increase in tubewells. According to Nair (1979), over 99 percent of the tubewells installed represented private investment of the cultivators. Tubewell irrigation has a distinct advantage over the canal irrigation system because groundwater supplies are influenced less by weather and other factors that affect surface water availability.[11] These guaranteed water supplies which can be applied in a timely fashion, became

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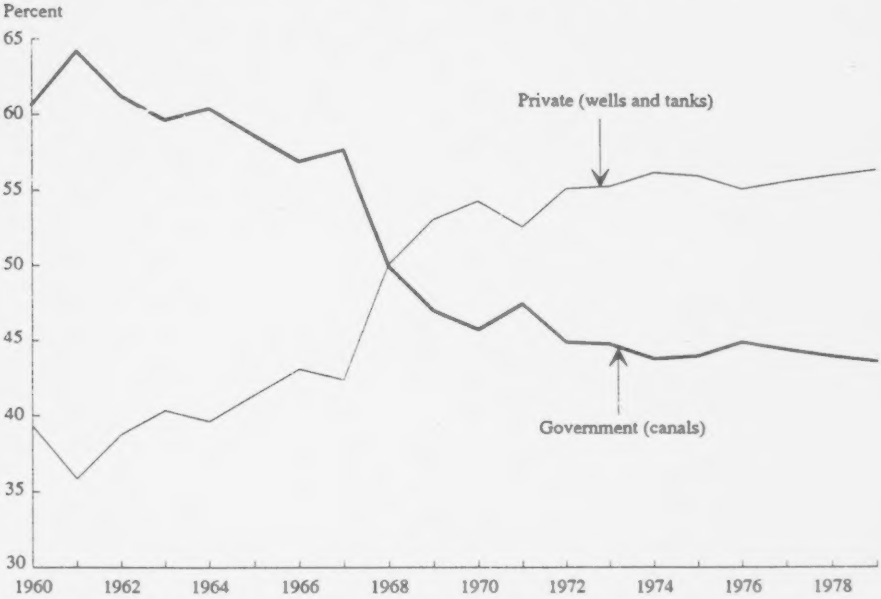
[10] No figure is provided for the *kharif* dry-season varieties because they occupy such a small proportion of the dry cropped area available.

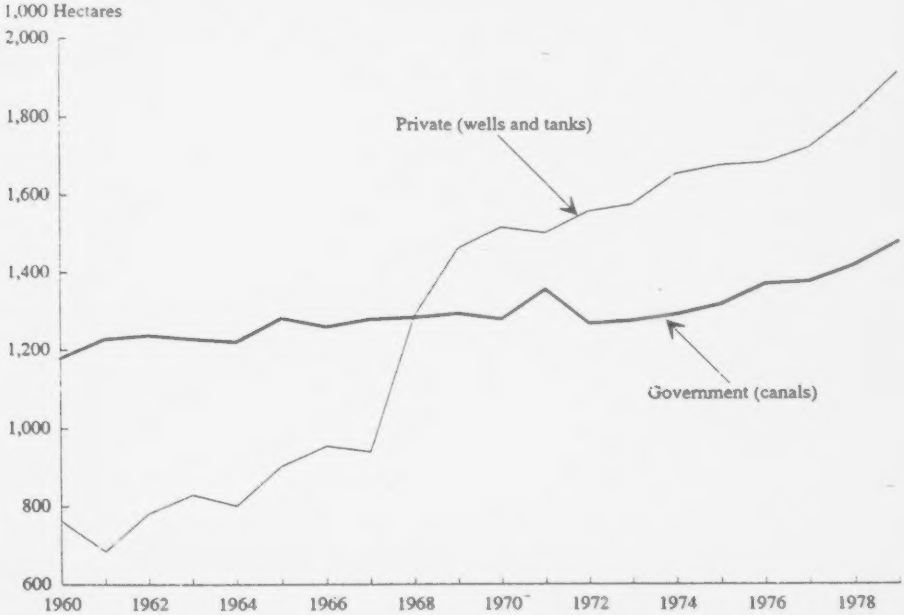
[11] Canal irrigation is less affected by weather in Punjab than in most places because of the Himalayan water sources.

## Figure 19 — Allocation of irrigated area in Punjab, by source, 1960-79



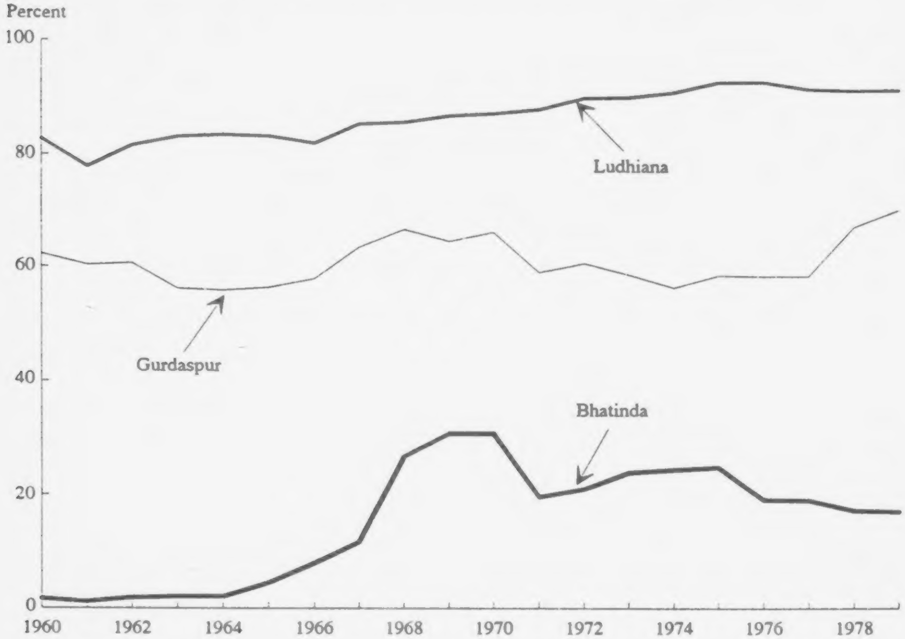
Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

## Figure 20 — Amount of irrigated area in Punjab, by source, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

Figure 21 — Net area irrigated by private wells in three districts, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

particularly important following the introduction of high-yielding varieties (Westley 1986).[12]

A full data series of the breakdown of area irrigated by type of well is not available, but it is known that as of 1959/60 there were an estimated 231,000 traditional wells and only about 5,000 tubewells in Punjab. By 1981/82, the number of tubewells increased to about 610,000, thus accounting for well over 90 percent of the total area irrigated by wells (Westley 1986).

Despite all the claims in the literature of the importance of various factors in facilitating the adoption of tubewells, empirical evidence for many of the claims is scanty. Conclusions drawn have varied, depending on the source of data and the area and time period studied. Evidence of the importance of institutional credit and availability of electricity for Punjab as a whole is found in a 1979/80 survey of tubewells and pumpsets (Punjab 1980). According to this survey, the importance of available institutional credit may be overstated, as over 75 percent of the financing for tubewells came from personal sources of the cultivators and only 10 percent from cooperatives. (The provision of credit is discussed in more detail in a later section.) The same survey indicated that in 1979/80, 30 percent of the tubewells and pumpsets were operated by electricity and 66 percent by diesel, despite the higher cost of diesel pumps. This phenomenon is attributed, first, to insufficient geographical coverage of electricity supply, and second, to disturbances in electricity supply (Mehra 1983). The electricity supply problems are discussed below.

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[12] Although the tubewell technology was available in pre-independence time, tubewells were not abundant in Punjab, as the technology was only developed for larger, inappropriately sized engines. Over time, small-scale engines and tubewells were developed and the economic situation changed, making the "minimum economically feasible size of holding" much smaller (Westley 1986). The end result of all these changes has been a substantial increase in area irrigated by tubewells.

The characteristics of the technology available and the economic conditions are not the only determinants of source and quantity of irrigation. There are also some physical limitations. In the hilly districts, for example, a much lower percentage of land is irrigated, because the digging of tubewells is difficult in the mountains, and because the availability of only seasonal streams makes the area unsuitable for canals. On the other hand, the western part of the state is more suitable for canal irrigation than well irrigation, since the water table is deeper and much of the water is brackish and unfit for tubewells. In the central part of the state, canal and tubewell irrigation are both suitable (Randhawa 1974).

Figure 21 shows the proportion of net irrigated area irrigated by wells for the three representative districts. Bhatinda, which is located in the southwestern portion of the state, has the lowest percentage of area irrigated by wells, whereas Ludhiana, which lies in the central plains, has the highest percentage of area irrigated by private sources.

## Electricity

From 1965/66 to 1979/80, power generation in Punjab increased by over 240 percent (Chadha 1986), and by 1976 all villages in Punjab had access to electricity (Mehra 1983). However, despite its general availability, Chadha (1986) estimates that by 1980/81, only 56 percent of the households were using electricity.

The fastest-growing source of demand for electricity during this period was agriculture. The proportion of total available electricity consumed by the agricultural sector increased from 14.5 percent in 1960/61 to 38.0 percent in 1970/71 and to 47.0 percent in 1979/80. A large part of the increase was as a source of power for the growing numbers of tubewells. According to Chaudhri and Dasgupta (1985), by 1975/76 as much as 43 percent of the power, whose cost was being subsidized by the Punjab State Electricity Board, was used specifically for tubewells.

Despite the impressive record of power generation, power has continued to be in short supply, and the gap between demand and supply has been widening. The growing number of applications for electrical connections pending is evidence of the shortage of power. In 1981/82, there were nearly 228,000 such applications, of which 34,000 had been waiting between one and two years, and 15,000 for over two years (Mehra 1983). Further, seasonal shortages and periods of low voltage sometimes occur in the busy summer months.

The problem has not only been one of increasing demand, but the supply has also been steadily deteriorating. According to Chadha (1986), there has been gross underutilization of installed capacity, partly because of recurring technical and management problems. Thus, although the government has played an important role in the provision of electric power, the availability of electricity still appears to be a constraint to agricultural growth.

## Credit

Because the new higher-yielding varieties require more purchased inputs than the traditional varieties, credit has become increasingly important in recent years. During the green revolution, both the central and state governments continued to influence the credit market through their involvement with credit cooperatives and other related policies. Consequently, it has been argued that "easily available agricultural credit financed very rapid expansion in the use of production inputs" (Westley 1986, 88), and it is believed that credit has been much more readily available in Punjab than anywhere else in India.

As a result of one policy—nationalization of the banking system in 1969—the commercial banks of India entered the agricultural finance scene. From 1972 to 1981 they doubled their share of loans outstanding to agriculture for both short-term credit (from 17 to 34 percent) and long-term credit (from 22 to 44 percent), while overall institutional credit to agriculture increased 18 percent. This new direction in the credit market has been particularly important for Punjab, as indicated by bank credit to agriculture of 533 rupees per hectare in Punjab in 1980, compared with 217 rupees per hectare for India as a whole (Westley 1986).

Although the credit cooperatives, which were established in the early twentieth century, were expanded significantly during the green revolution, much of the literature is skeptical about the effectiveness of these institutions. Even though credit cooperatives increased their proportion of rural credit from 3 to 33 percent between the early 1950s and late 1970s, it is feared that they did not replace the traditional money lender as intended (Westley 1986). Mellor (1976, 38) argues that in India, as elsewhere in the developing world, credit cooperatives ". . . must still be seen more as a means of dispensing political patronage than as a development institution." The importance of credit as a constraint to purchases of fertilizers and seed and to investment in irrigation, mechanization, and so forth, is not analyzed explicitly in this study.

## Fertilizer

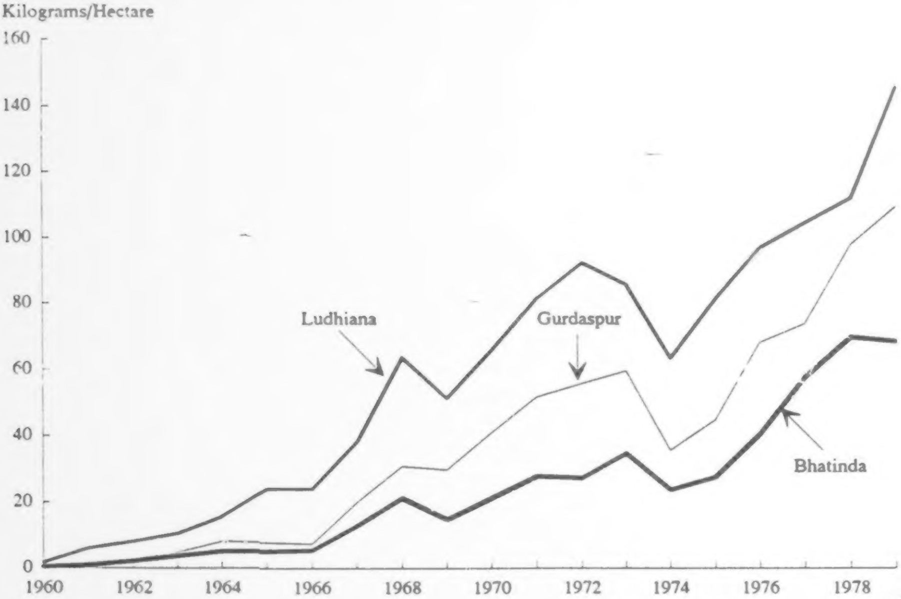
Until the early 1960s, commercial fertilizer use was extremely low. Chadha (1986) provides two reasons for these low levels of fertilization. First, the traditional seeds, in use up to this time, were not responsive to high fertilization rates, thus returns were too low to justify the expenditure on this costly input. Second, the extension services were not "up to the task," and there was a lack of adequate information on the fertilizer requirements of the different soils. The second reason implicitly assumes that the weak response to fertilizer is due to lack of knowledge. This may or may not be the case, but as it is not an important issue for this discussion it is not pursued further.

Because high-yielding varieties respond well to fertilization, once they were introduced, the use of fertilizer increased dramatically. For the districts included in this study, application of fertilizer per hectare increased from 1 kilogram in 1960 to 105 kilograms in 1979. The 1979 figure is almost as large as that for the United States (110 kilograms) and is 3.5 times the all-India consumption per hectare for the same year.

Figure 22 illustrates the trend in fertilizer use per cropped hectare in Bhatinda, Ludhiana, and Gurdaspur during 1960/61-1979/80. Not only is the increase in fertilizer use extraordinary, but so is the variation in usage by district. Consumption rates per hectare increased from almost zero for all three districts to 140 kilograms in Ludhiana, over 100 kilograms in Gurdaspur, but only 60 kilograms in Bhatinda.

The availability of tubewells is thought to have influenced the demand for fertilizer, because the assurance of adequate and timely water through use of tubewells allows more effective use of fertilizers (Chadha 1986).

**Figure 22 — Fertilizer per cropped hectare in three districts, 1960-79**



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

It appears that despite the great increase in fertilizer use, in general, "sub-optimal" levels are still being used (Kahlon 1984; Kahlon and Kaul 1968). Some believe the use of fertilizer has been determined by its availability rather than factors affecting demand. For example, Nicholson (1984, 150) argues, "it was probably not the local distribution system that affected the access of the poor to inputs, but the allocation of fertilizer within the federal system by the national government, which created localized conditions of scarcity and plenty." For other views see Desai 1982.

## Mechanization

Although the increase in mechanization in Punjab is often associated with the onset of the green revolution, there had been a substantial increase in the use of tractors before 1966. Table 3 illustrates the growth in tractors for Ludhiana, Bhatinda, and Patiala, as well as for Punjab as a whole, from 1956 to 1978. As can be seen, the increase in the number of tractors has been phenomenal.

Many reasons have been cited for the increase in mechanization: subsidization of tractors by the government, availability of cheap institutional credit, and large remittances from abroad (Chadha 1986). In addition to these factors, the growth in agricultural productivity during the green revolution helped make tractors profitable in situations where they had not previously been economically viable. However, scarcity of labor, which is largely seasonal in nature, is mentioned most often as the main reason for increased mechanization.

Binswanger (1978) argues that increases in wages have been responsible for the increase in mechanization. However, data on tractor availability indicate that the number of tractors increased considerably just prior to the green revolution, when real wages reached their all time low (see below). Further, the demand for labor increased during the green revolution, but as Schwarz (1986) notes, this increase in demand was met to a large extent by labor migration to Punjab from other states and thus prevented wages from reflecting the full impact of the increased demand.

However, market wages may not tell the whole story. If hired labor and operator labor are not perfect substitutes, then mechanization may have allowed

**Table 3—Index of tractor numbers in Punjab agriculture, 1956-78**

| District | 1956 | 1961 | 1966 | 1972 | 1978 |
|---|---|---|---|---|---|
| Ludhiana | 100.00 | 181.69 | 1,144.37 | 3,354.93 | 8,059.86 |
| Bhatinda[a] | . . . | 100.00 | 96.18 | 238.85 | 829.31 |
| Patiala | 100.00 | 124.39 | 215.96 | 978.80 | 2,507.76 |
| Punjab | 100.00 | 169.64 | 365.62 | 1,414.78 | 3,380.72 |

Source: Based on data from G. K. Chadha, *The State and Rural Economic Transformation: A Study of Punjab, 1950-1985* (New Delhi: Sage, 1986).

[a] Bhatinda data have not been adjusted for boundary changes.

better use of the operators' time. Thus it may have been an increase in the shadow wage rate of the farmers' time that generated the demand for tractors. This explanation is consistent with the argument that the demand for timely completion of field operations led to increased mechanization (Kahlon 1984). Unfortunately, data on numbers of tractors are not available on an annual basis; therefore, the importance of mechanization is not analyzed explicitly in this study.

## Labor

A consistent time series is not available for labor in Punjab, so it is difficult to analyze the changes in the agricultural labor force that have occurred over time. Data are available every 10 years from the Indian census. These series are not completely consistent, as definitions have changed over time.

Despite a negligible change in the number of agricultural workers as a percentage of total workers, there has been a significant change in the composition of agricultural workers. In Table 4 the number of male agricultural laborers is disaggregated into two groups, cultivators and agricultural laborers, and changes in these groups are shown for 1961 to 1981 in both Punjab and India. The total number of male agricultural workers in Punjab grew 2.2 percent annually (compounded) during 1961-81, while the number of agricultural laborers grew 6.1 percent and the number of cultivators less than 1.0 percent. The all-India data exhibit similar trends, with the interesting exception that during 1971-81 the proportion of agricultural laborers in India declined. Thus, in comparison with the country as a whole, the agricultural growth in Punjab generated a large demand for laborers.

Although this study does not deal with the impact of migration on the changes that have occurred, and vice versa, the substantial migration that took place needs

**Table 4—Occupational classification of rural male workers, 1961-81**

| | 1961 | | 1971 | | 1981 | |
|---|---|---|---|---|---|---|
| Occupation | Number | Percent | Number | Percent | Number | Percent |
| | (thousands) | | (thousands) | | (thousands) | |
| Punjab | | | | | | |
| Cultivators | 1,424 | 57.8 | 1,610 | 54.1 | 1,662 | 49.8 |
| Agricultural laborers | 307 | 12.5 | 739 | 24.9 | 967 | 29.8 |
| Other | 731 | 29.7 | 625 | 21.0 | 708 | 21.8 |
| Total | 2,462 | 100.0 | 2,974 | 100.0 | 3,337 | 100.0 |
| | (millions) | | (millions) | | (millions) | |
| India | | | | | | |
| Cultivators | 62.5 | 60.7 | 64.5 | 55.5 | 74.1 | 55.3 |
| Agricultural laborers | 16.7 | 16.2 | 30.0 | 25.8 | 27.5 | 24.2 |
| Other | 23.8 | 23.1 | 21.6 | 18.6 | 27.5 | 20.5 |
| Total | 102.9 | 100.0 | 116.0 | 100.0 | 134.1 | 100.0 |

Source: Based on data from John R. Westley, *Agriculture and Equitable Growth: The Case of Punjab-Haryana* (Boulder, Colo., U.S.A.: Westview, 1986).

Note: Parts may not add to totals because of rounding.

to be mentioned. For years, Punjab has attracted labor from the neighboring states of Uttar Pradesh, Jammu and Kashmir, and Rajasthan. During the green revolution the number of migrants increased substantially, and they have started to come from places as far away as Bihar, Orissa, and Madhya Pradesh (Grewal and Sidhu 1979). Unfortunately, the available data describing the changes in the flow of labor from outside Punjab are sparse. For a more detailed analysis of labor see Schwarz 1986.

## Price Policy and Prices

The key instrument in the agricultural pricing policy in India is the price at which the government procures foodgrains for the public distribution system.[13] The main features of this system, including restrictions on grain movement between regions, government procurement in surplus districts, distribution and rationing in urban areas, and administrative control over traders, date from the Bengal Famine of 1943 and have been applied in various combinations in response to changes in the volume of agricultural production. A major change took place in this policy during the 1960s with the establishment of the Agricultural Prices Commission. This Commission set procurement prices at a level remunerative to farmers to promote greater reliance on domestic, rather than imported, supplies of foodgrain for the public distribution system (Westley 1986).

This greater reliance on domestic sources of foodgrain for public distribution led to a significant increase in Punjab's contribution of foodgrain to this program. From the early 1950s to the mid-1960s, foodgrain procurement from Punjab averaged less than 5 percent of the wheat crop and approximately 33 percent of the rice crop. During the 1970s, however, government procurement accounted for approximately one-third of its wheat production and about three-quarters of its rice production (Krishna and Raychaudhuri 1980). As of 1980/81, Punjab's contribution was 45 and 64 percent of the rice and wheat procurements, respectively (Westley 1986).

The increase in tonnage of crops moving through the regulated markets in response to the new procurement policy of the 1960s caused serious problems. In response to these problems, the state government established additional markets and continued with its "crash" road program. By the mid-1970s, every village in the region was connected to market by its own all-weather road (Chadha 1986), and Punjab now has the most fully developed physical infrastructure for marketing in all of India (Westley 1986).

By essentially providing a guaranteed market for Punjabi foodgrain production, the procurement policy has helped sustain the growth in the agricultural sector without relying heavily on income-driven demand increases from the nonagricultural sector. Thus, Punjabi efforts have continued to be heavily biased toward the agricultural sector.

The foodgrain procurement program generally has relied heavily on market incentives, but on some occasions the government has intervened through various zonal restrictions on foodgrain movement. In 1973 these restrictions were taken to extremes as the government attempted a complete takeover of the wheat trade to ensure higher procurement levels. This full-control policy was quickly abandoned in 1974, and by 1977 the zonal restrictions were abandoned altogether. Since then, the government has generally purchased all grain offered at the procurement price, and this price has acted as a support price (Westley 1986).

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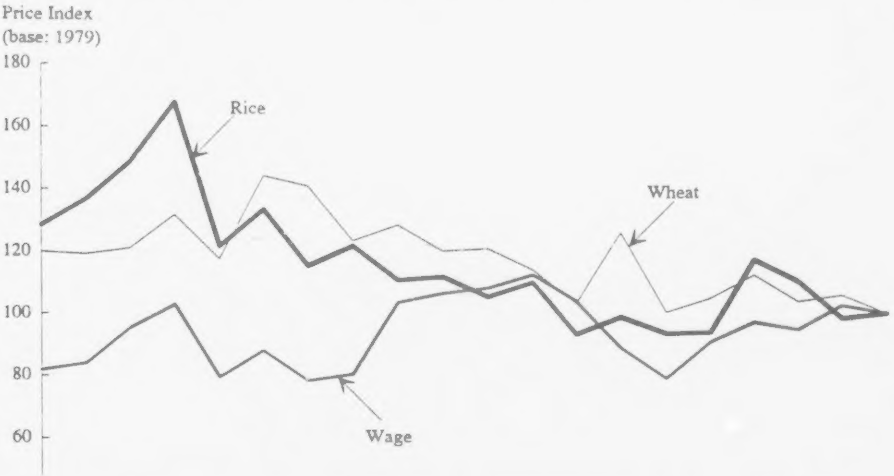
[13] For a review and description of the agricultural price policies in India see Kahlon and Tyagi 1983.

Although the Agricultural Prices Commission sets procurement price levels, these prices are strictly speaking only recommendations, and states have some flexibility in setting their own prices. Since 1965, Punjab has generally set its prices slightly above the recommended levels (Krishna and Raychaudhuri 1980). Chadha (1986) provides evidence that the prices set by the state government in recent years have been greater than the cost of production (including rent for leased land and imputed costs for all family resources) for both wheat and rice. His figures indicate that during the green revolution the procurement price of wheat was as much as 42 percent higher than costs in 1967/68 and as little as 8 percent higher in 1975/76. This is in sharp contrast to the 1950s, when the full cost of wheat production was covered by only a small margin on some irrigated tracts.

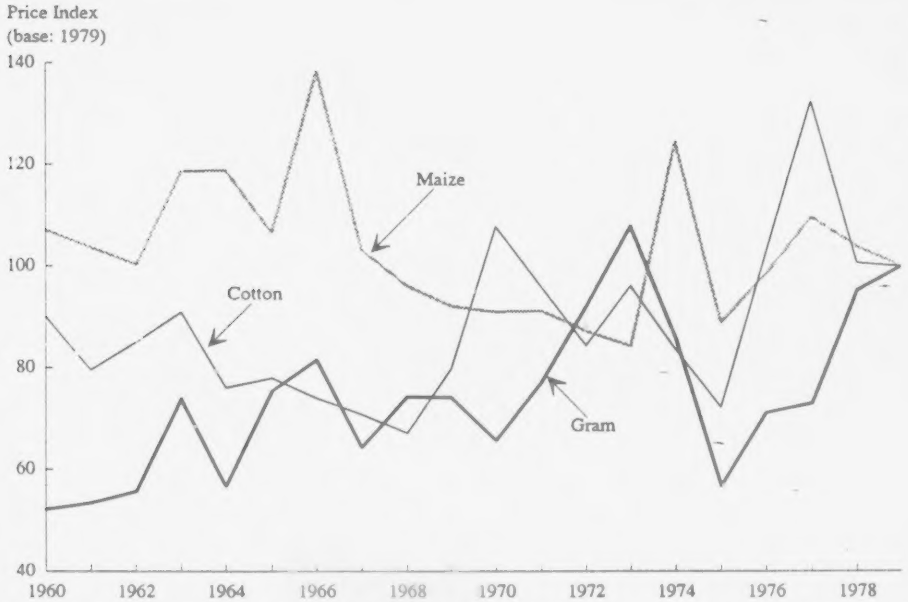
Figures 23 and 24 report the real mean wage rate and prices of all the crops analyzed in this study for all districts. Each price series is deflated by its own 1979 price. Figures 25 and 26 present the real harvest price of wheat and rice for the districts of Bhatinda, Ludhiana, and Gurdaspur. These prices are deflated by the consumer price index for Punjab (base = 1960/61).

Figure 23 – Average wage and harvest prices for wheat and rice in Punjab, 1960-79



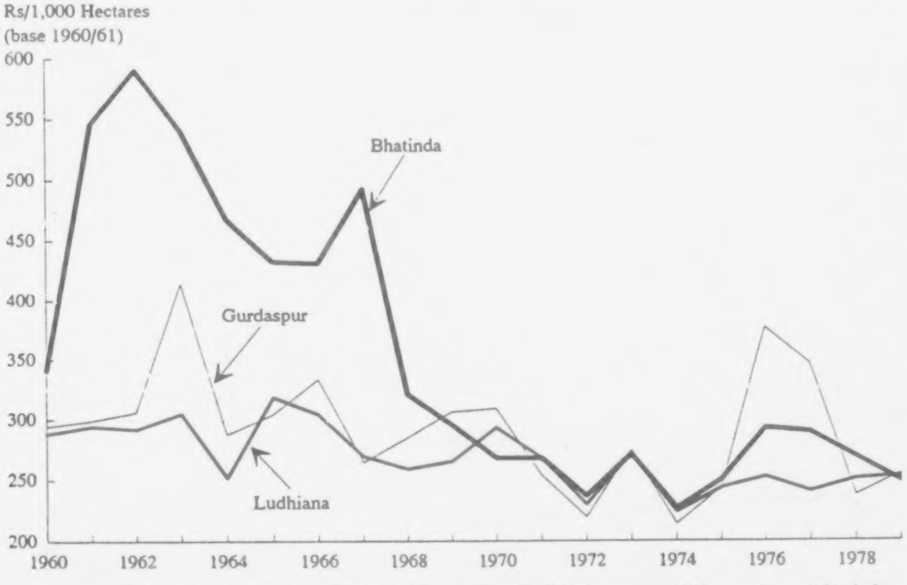
Source: India, *Farm (Harvest) Prices of Principal Crop* (New Delhi: Directorate of Economics and Statistics, various years).

Figure 24 — Average harvest prices for maize, cotton, and gram in Punjab, 1960-79



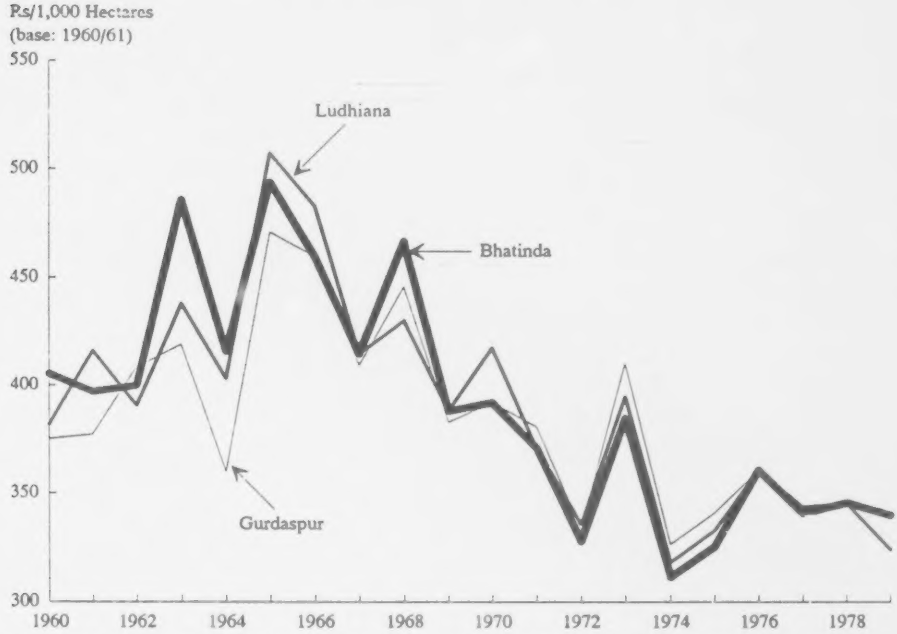
Source: India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

Figure 25 — Real rice price in three districts, 1960-79



Source: India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

**Figure 26—Real wheat price in three districts, 1960-79**



Source: India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

As is evident from these plots, the movement in real prices has varied considerably over time. However, most striking is the declining trend in the prices of wheat and rice that began in the mid-1960s. The price of wheat increased somewhat in 1973, but returned to the trend line in the subsequent year. The downward trend in wheat price roughly followed that in world prices and was facilitated by increases in domestic production.

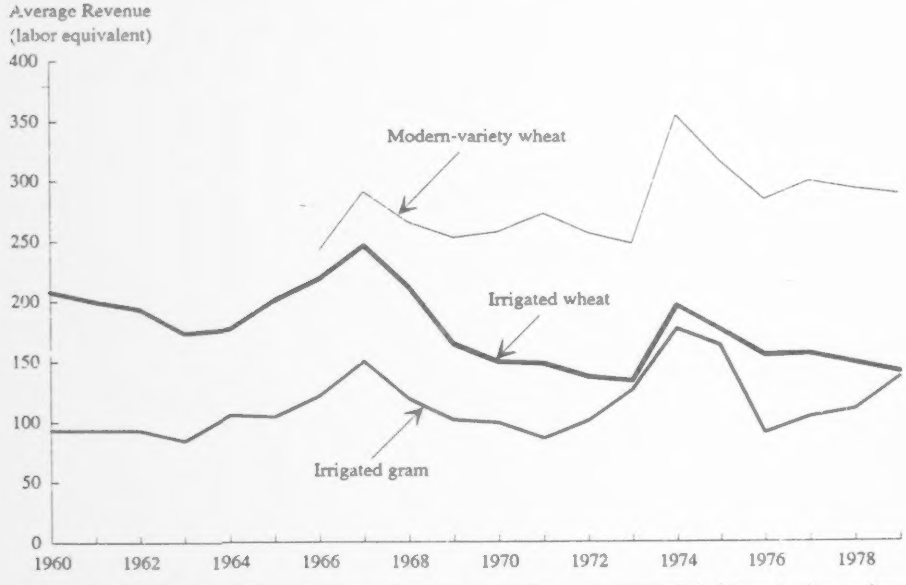
Figure 23 indicates that mean real wages reached an all-time low just before the onset of the green revolution. Wages then trended upward until the early 1970s. Following this increase, they declined until 1974. Some of this decline may be attributed to poor weather conditions. Thereafter, real wages begin to recover, but not sufficiently to surpass the peak in the early 1970s.

## Expected Revenues

As explained in Chapter 5, a measure of expected revenue per hectare (deflated by the wage rate) is used as an indicator of the profitability of the different crop varieties. Expected revenues for the different crops (by techniques) in the *rabi* and *kharif* seasons are presented in Figures 27-30.[14] For the most part, the yields of all the traditional varieties (irrigated and dry) are constant over the sample period; thus, changes in the expected revenues of these varieties reflect changes in the expected prices (see Appendix 2 for a detailed discussion of the construction of these variables). Note that the expected revenue variables referred to here as MV wheat and rice expected revenues are the expected overall average revenue for wheat and rice, as changes in expected overall yields reflect changes in the yields of the MVs and changes in their share in total area.

The relative ranking of the *rabi* season crops according to average revenue is obvious—MV wheat dominates all other crops and techniques. Although the expected revenue of irrigated cotton in the *kharif* season has been very large throughout the sample period, the expected revenue of MV rice has surpassed it since 1973 (Figure 29). In terms of expected revenue during the last few years of the sample, dry cotton has outperformed irrigated and dry maize, which in turn have outperformed irrigated and dry rice. Although the range in expected revenues has expanded over the sample period, the ranking of the different crops for the most part has remained the same since 1969.

**Figure 27 — Expected revenues for irrigated wheat and gram and modern-variety wheat, rabi season, 1960-79**



Sources: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years); and India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

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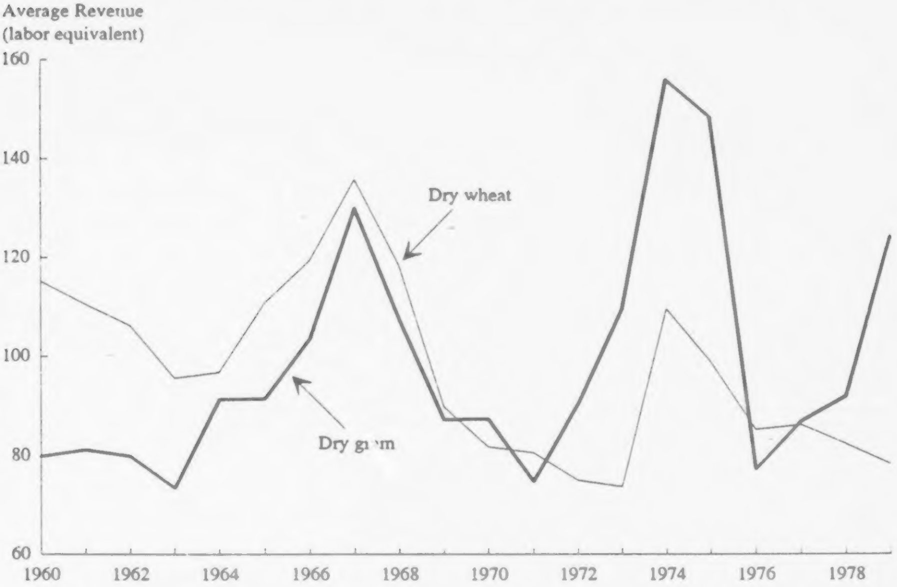
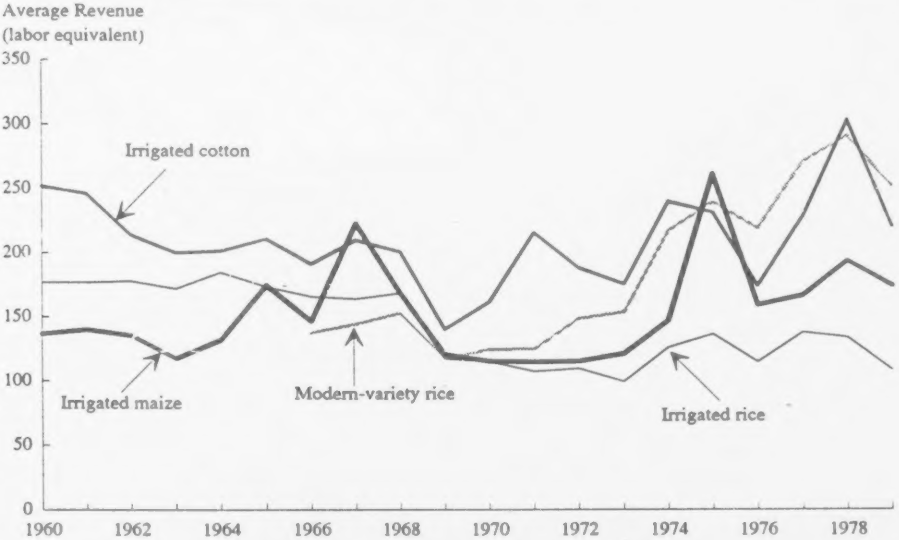
[14] All expected revenue variables (Rs/1,000 hectares) are deflated by wage (Rs/8-hour day).

## Figure 28 — Expected revenues for dry wheat and gram, rabi season, 1960-79



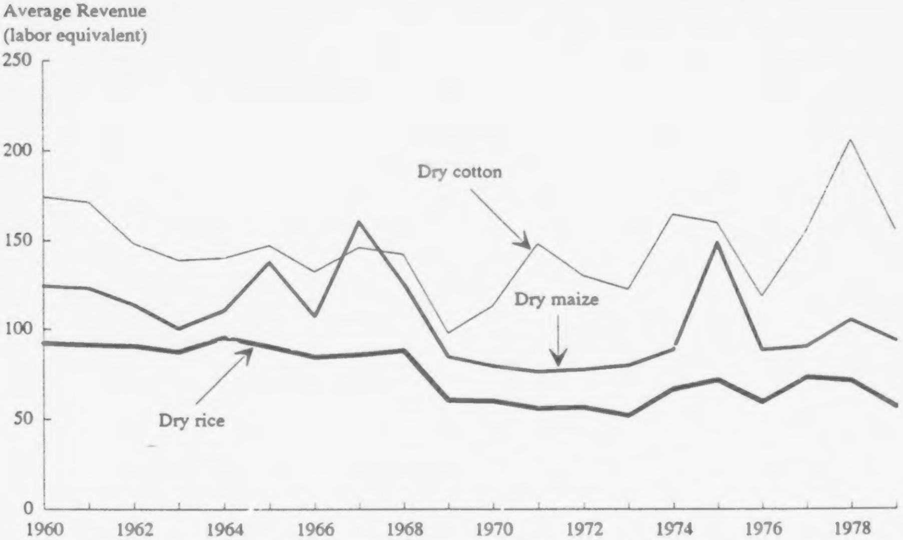
Sources: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years); and India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

## Figure 29 — Expected revenues for irrigated rice, maize, and cotton and modern-variety rice, kharif season, 1960-79



Sources: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years); and India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

**Figure 30 — Expected revenues for dry rice, maize, and cotton, kharif season, 1960-79**



Sources: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years); and India, *Farm (Harvest) Prices of Principal Crops* (New Delhi: Directorate of Economics and Statistics, various years).

## Summary and Conclusions

Much of the rapid growth in NDP experienced by Punjab during the period of study was generated by growth in agriculture that was largely due to growth in crop production resulting from improvements in the overall yields of wheat and rice and, to a lesser extent, improvements in the yields of maize and cotton. The pattern of growth in overall yields for the various crops, particularly wheat and rice, suggests that the main improvements came as a result of a shift to the new higher-yielding varieties rather than as a result of intensified cultivation of the existing varieties.

The pattern of transition from the traditional varieties to the MVs varied significantly by crop. The adoption of the new varieties was very fast in wheat, while the adoption of MV rice was initially somewhat slow, as the new rice varieties could not be integrated easily into the existing cropping practices. Once suitable varieties were introduced, however, adoption of MV rice was rapid. In the case of maize, lack of disease- and drought-resistant varieties prevented the new varieties from assuming a significant share of area planted in corn.

The extremely rapid adoption of MV wheat—and also of MV rice, once the more suitable rice varieties were introduced—indicates that factors usually associated with the rate of implementation of new technologies, such as imperfect information, uncertainty, institutional constraints, and the availability of human capital, did not play a prominent role in the adoption process. That is, these factors could not have changed much over the extremely short transition period and therefore could not have influenced the rate of adoption. It appears that the dominance of the new varieties was well perceived by all. Alternatively, the speed at which the new varieties were adopted, particularly MV wheat, suggests that the pace of transition was largely determined by physical constraints such as, initially, the availability of seeds, and later on, the availability of irrigation facilities and fertilizers.

The introduction of the new varieties was associated with an expansion in (net) cultivated land, (net) irrigated area, and the intensity of cultivation and irrigation, as measured by the ratio of gross to net cultivated and irrigated areas. The increase in irrigated area came about mainly by a substantial expansion in the number of tubewells.

The expansion of agricultural production increased the demand for labor considerably. This increase in demand was met largely by migration of labor from other states and thus did not lead to a substantial increase in the wage rates of hired labor. On the other hand, the increases in hired labor and value of production per hectare raised the marginal productivity of the operators' own time, and this in turn led to an increase in mechanization.

The real harvest prices of wheat and rice trended downward, reflecting not only the trend in world prices but also the increase in domestic production. When a decline in prices is accompanied by an increase in production, often the conclusion drawn is that incentives, or more specifically, prices, play no role in the production decisions by farmers. However, this conclusion is based on association and not causality. To overcome it, average revenue per hectare for the various crop varieties is a better measure of incentives than price for each particular crop. This measure of incentives indicates a substantial advantage of the MVs over the traditional varieties and thus helps explain the rate at which these varieties were adopted.

The effects of the physical environment, the initial levels of infrastructure, and the availability of human capital on choice of technique and overall level of output can be detected by making cross-district comparisons. Such comparisons provide an additional dimension to the time series variations and thus are used in the subsequent empirical analysis.

## 4

# THE CONCEPTUAL FRAMEWORK

The main event in Punjab during the period under consideration is the introduction of the MVs of wheat, rice, and maize. An analysis of this period must explicitly take into account the effect of the change in technology on product supply and input demand. Such an approach, outlined in Mundlak (1987, 1988), is followed here.

Output is determined by inputs and technology. Given the available technology, the selected level of variable inputs depends on product and factor prices and constraints. Included among the constraints are quasi-fixed inputs, or inputs that cannot vary immediately, regardless of the reason, in response to price variations.

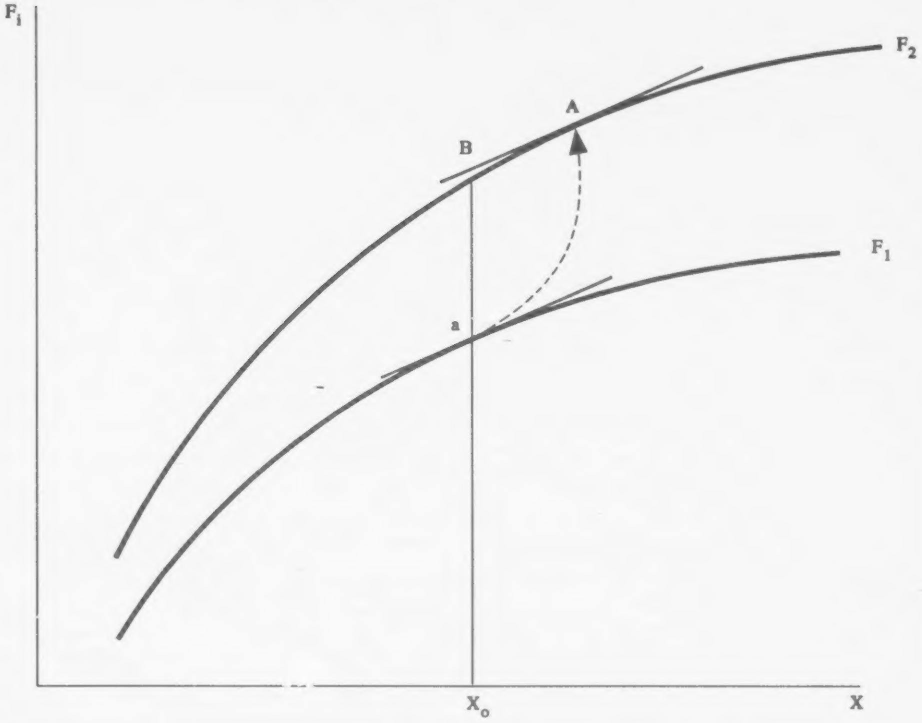
Technology is viewed as a collection of techniques, each technique being represented by a production function. The available technology set contains all the techniques that potentially can be used, whereas the implemented technology set contains those techniques that actually are implemented. Data on inputs and output describe only the implemented technology. Thus the distinction between available and implemented technology has important implications for empirical analyses. To illustrate, Figure 31 presents two production functions, $F_1$ and $F_2$, where the output of a given product is drawn as a function of a single input. All other inputs are assumed to be constant. The tangent lines represent a given market price. If the available technology consists of the two techniques, $F_1$ and $F_2$, and there are no other constraints to production, $F_2$ will be implemented as it dominates $F_1$. Consequently, data on inputs and output will describe $F_2$ only.

To examine cases where the data consist of observations describing more than one technique, suppose that a set of time series data that can be divided into two subperiods is obtained. In the first subperiod the technology consists only of $F_1$, and thus, given the market price illustrated, the observations will be clustered around point a. Now suppose that $F_2$ is introduced in the second subperiod and that producers move to employ the advanced technique generating observations clustered around point A. A sample consisting of the two clusters around a and A will not give an empirical production function that is identical with either one of the functions. The marginal productivity of the input will be exaggerated, and it is quite possible that the function will appear to be convex, rather than concave, in the input.

This presentation is so elementary that there can be no dispute that an explicit recognition of the relevant technology should be part of the analysis. In principle, this could be done by analyzing the data of the two subperiods separately. However, the implementation is not that simple when there is a period where the two techniques coexist. Ignoring the period of coexistence results in a loss of valuable information. Specifically, the important determinants of the speed of transformation to different techniques cannot be determined.

The transition to a new technique of production may be gradual for a variety of reasons: costs of adjustment, constraints to complete adoption, uncertainty about

**Figure 31—Domination of old technique by new technique**



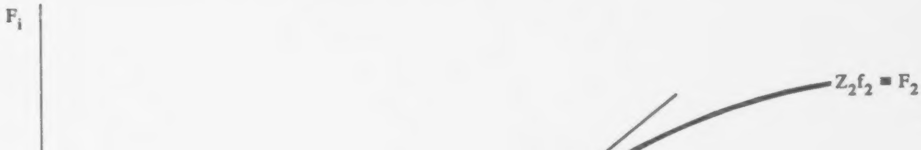
the new technique, and insufficient information. For an illustration, see Figure 31 and suppose that initially the level of input is $X_o$, and that this level cannot be changed in the short run. The movement to $F_2$ results in observations clustered around point B. The convergence to B may be gradual or incomplete for any of the reasons described. During the period of adjustment, observations will be scattered along the line segment aB. The average output per unit of X will trend upward as the share of $F_2$ in total output increases. The only way to explain this change of output is to relate it to the extent to which the advanced technique has been implemented. Therefore, to explain the rise in output, it is necessary to explain the pace of transition to the advanced technique.

Another possible scenario following the introduction of $F_2$ is that larger quantities of X become available as producers shift to the advanced technique. In this case, it is possible to obtain a path of convergence such as that observed in Figure 31 joining points a and A. Under this scenario, the average output per unit of X will be a function of X and the share of $F_2$ in total output. Again, an explanation of the rise in output requires an explanation of the pace of adjustment toward the new technique.

This study focuses on the extreme importance of resource scarcity in determining the transition process. The transformation to new techniques usually requires resources, and as a consequence the new more productive technique that dominates the traditional technique does not fully replace it immediately; the two techniques may coexist for a long time. For an illustration, see Figure 32, where the new technique ($F_2$) dominates the old technique ($F_1$) only for certain levels of inputs. Assume that the two techniques are represented by linear homogeneous production functions in land (Z) and an aggregate input (X). Let $Y_i$, $X_i$, and $Z_i$ denote the output of, and quantities of, X and Z used by technique i, respectively. Then write $Y_i = Z_i f_i(x_i)$, where $x_i = X_i/Z_i$.

The implementation of the techniques will now depend on x, which represents the availability of X relative to Z. Obviously, when $x \leq x_a$, only $F_1$ will be employed, whereas when $x \geq x_A$, only $F_2$ will be employed. However, when $x_a \leq x \leq x_A$, the two techniques coexist. Given the linear homogeneity assumption for $F_1$ and $F_2$, it can be shown that the relevant production function for $x_a \leq x \leq x_A$ is $f(x) = \lambda f_1(x_1) + (1-\lambda) f_2(x_2)$, where $\lambda = Z_1/Z$, and $Z_1 + Z_2 = Z$ (see Danin and Mundlak 1979 and Mundlak 1988). That is, the introduction of $F_2$ facilitates the coexistence of the two techniques when the aggregate input to land ratio lies within the interval $(x_a, x_A)$. For instance, if x is fixed at $\bar{x}$, output can increase from $Y_1$ to $\overline{Y}$ by shifting some resources from the traditional technique, $F_1$, to the advanced technique, $F_2$.

Figure 32—Coexistence of old and new techniques



Given the discussion above, it is clear that the shape of the empirical production function fitted to data will depend on the distributions of prices and resource constraints prior to, and after, the introduction of the new technique. Given this framework, it is easy to illustrate how an empirical production function that does not explicitly recognize the existence of the different techniques will provide a distorted view of the underlying technology. Thus it is important to identify the underlying technology and constraints in order to obtain a useful empirical description of the production process. Failure to do so may distort considerably the view of the growth process and give results that do not make economic sense, including the wrong concavity of production or profit functions, as is often the case in empirical studies.

## The Optimization Framework

The underlying optimization problem calls for a choice of inputs $v_j, b_j$ that maximize the lagrangian function L:[15]

$$L = \Sigma_j p_j F_j \, (v_j, b_j, E) - \Sigma_j w v_j + \lambda \, (b - \Sigma_j b_j), \tag{1}$$

so that $F_j(\cdot) \, \varepsilon T$,

where

$T$ = the set of all available techniques, or simply, available technology;

$p_j$ = the price of the product of technique j;

$w$ = the vector of prices of the variable factors ($v_j$);

$b$ = the value of the constraint for the fixed factors of production that are allocated to the various techniques ($b_j$);

$E$ = the relevant characteristics of the environment in which technique j is implemented; and

$\lambda$ = a vector of shadow prices for the constraints.

The Kuhn-Tucker necessary conditions for a solution are

$$L_{v_j} = p_j F_{v_j} - w \leq 0, \tag{2}$$

$$L_{b_j} = p_j F_{b_j} - \lambda \leq 0, \tag{3}$$

$$\Sigma \, (L_{v_j} v_j + L_{b_j} b_j) = 0, \tag{4}$$

$$v_j \geq 0, \, b_j \geq 0, \tag{5}$$

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[15] This optimization is made conditional on prices and does not deal specifically with the allocation of the quasi-fixed factors among farms. However, the solution at the aggregate level is equal to that achieved by a competitive system.

$$L_\lambda = \Sigma b_j - b \le 0, \tag{6}$$

$$\lambda L_\lambda = 0, \tag{7}$$

where $L_{v_j}$, $F_{v_j}$, $F_{b_j}$, $L_{b_j}$, and $L_\lambda$ are vectors of the first partial derivatives. The solution can be described as

$$v_j^*(s), b_j^*(s), \lambda_j^*(s),$$

where s represents the exogenous variables of this problem, which will be referred to as the state variables (s):

$$s = (b,p,w,E,T). \tag{8}$$

The solution to the maximization problem thus depends on the available technology (T), the environment (E), the constraints (b), and the product and variable input prices. It is important to note that the solution determines both the techniques used and the level of their use, as determined by the optimal allocation of fixed inputs $(b_j^*)$ and variable inputs $(v_j^*)$. This can be seen by rearranging equations (2), (3), and (4):

$$\Sigma_j (p_j F_{v_j} - w_j) v_j + \Sigma_j (p_j F_{b_j} - \lambda) b_j = 0. \tag{9}$$

If equation (2) or equation (3) is negative, then $v_j^* = 0$ or $b_j^* = 0$, respectively. The optimal output of technique j is $y_j^* = F_j(v_j^*, b_j^*, E)$. The implemented technology (IT), the collection of all implemented techniques, is a subset of T. As such, the envelope of IT is in general not the same as the envelope of T. The difference, of course, is due to the constraints encountered by the decisionmaker.

The implemented technology, IT, can be described formally by

$$IT(b,p,w,E,T) = \{F_j(v_j,b_j,E) \mid [F_j(v_j^*,b_j^*,E) > 0], F_j \varepsilon T\}. \tag{10}$$

The number of implemented techniques depends on the number of constraints or the dimensionality of b. In this general formulation, no limit is set on the number of state variables except that it is finite. Thus it is possible to apply the formulation to a variety of applications.

Given the usual regularity conditions for $F_j$ and given a particular set of state variables, equation (9) describes a well-behaved technology. Consequently, a profit function can be derived:

$$\pi(s) = \Sigma p_j F_j(v_j^*(s), b_j^*(s), E) - \Sigma w_j v_j^*(s). \tag{11}$$

The various theorems dealing with the duality between the profit function and the production function hold true conditional on s. Specifically, the frontier of IT(s) is dual to π(s) and vice versa.[16] Using Hotelling's lemma, the factor demand is

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[16] It is important to note that the exploitation of this property in empirical analysis is restricted because s varies over the sample. Thus, strictly speaking, each point in the sample comes from a different profit function, which in turn describes a different set of implemented technology.

$$-\frac{\partial \pi(s)}{\partial w} = v^*(s). \tag{12}$$

Note that (12) expresses the input demand aggregated over techniques.

Similarly, the supply of output of technique j is given by

$$y_j^*(s) = \frac{\partial \pi(s)}{\partial p_j}. \tag{13}$$

If there is more than one technique producing a given crop, then

$$\frac{\partial \pi(s)}{\partial p_i} = \Sigma_j y_{ji}^* = y_i^*, \tag{14}$$

where $y_{ji}^*$ is the j^th^ technique used to produce the i^th^ crop and $y_i^*$ is the total output of crop i. Finally, the aggregate value of supply is given by

$$y^*(s) = \Sigma p_i y_i^*(s). \tag{15}$$

It is important to note that, within this framework, a change in a state variable generates two effects on the optimal variable inputs and outputs. First, a change in a state variable may lead to variations in the optimal combinations of inputs and outputs along a given production function. This intratechnique effect is the effect usually considered in supply analyses. The second effect due to a change in a state variable describes the change in the optimal composition of techniques. It is referred to here as the intertechnique effect. The impact of these two effects on the relationship between changes in state variables and output by crop may be very different. Thus, a distinction between these two effects and an understanding of the relative importance of these effects is necessary to fully understand growth in output for crops that can be produced by more than one technique.

## Optimization by Stages: Area and Yield

In general, production is not instantaneous, so input usage decisions can be revised as the information set changes. In terms of crop production, farmers decide how to allocate their area among the different crops and techniques given their information set at the time of planting (Mundlak 1963; Antle 1983). Once the crop has been planted, farmers can change output only by influencing yield. The extent to which yield, and thus output, can be altered later in the production process can only be determined empirically.

In terms of the crop production decisions, it is assumed that at stage 1 the optimization described by equation (1) is used to determine the initial allocations of land and other fixed inputs to the various techniques. Stage 2 of the decision problem can be formulated similarly except that this decision is made conditional on the optimal area allocations chosen in stage 1. That is, the optimal area allocations are included among the relevant state variables in the stage 2 decisions. To be more explicit, the vector of the state variables for stage 1 of the optimization problem is

$$s^1 = (b^1, p^1, w^1, E, T), \tag{16}$$

where $b^1$, $p^1$, and $w^1$ represent the constraints and the expected product and input prices at planting time, respectively. The state variables for the stage 2 optimization problem are

$$s^2 = (b^2, p^2, w^2, E, T), \tag{17}$$

where $b^2$ differs from $b^1$ in that it contains, among the other constraints, the area allocated to each crop and technique in stage 1 rather than the total area available, that is, $b^2$ contains $A_j = A_j(s^1)$. Further, $p^2$ and $w^2$ are producers' updated expected product and input prices. Consequently, the optimal inputs of stage 2 are functions of $s^2$ and $s^1$, and the optimal output can be written as

$$Q_j^* = F_j(A_j(s^1), v_j(s^1,s^2), b_j(s^1,s^2)). \tag{18}$$

Note that, within this framework, area is introduced explicitly as an input into the production function. Further, the other inputs are taken as the sum of their usage in the two stages, as input data are not detailed by stages.

Assuming that the production function is constant returns to scale in the inputs, equation (18) can be rewritten as a product of area and yield:

$$Q_j = A_j(s^1)\, Y_j(s^1,s^2). \tag{19}$$

The two components of equation (19), yield and area, can be estimated separately.

## Quasi-Fixed Inputs

The decisions by producers to alter the availability of quasi-fixed inputs take into account the anticipated effect of changes in these inputs on costs and revenues over the lifetime of the investment.[17] The effect of these decisions on future streams of income distinguishes these longer-run decisions from the short-run decisions previously analyzed. It is this difference that allows the formulation of the decision process as a recursive problem that can be estimated in stages (Mundlak 1967). Such formulations of the investment decision are now common in the estimation of dynamic factor demand equations (compare Berndt and Field 1981).

To illustrate the recursive approach, consider a simple intertemporal optimization problem. Suppose there is only one output production function, $Q = F(v,K,T)$, where $v$ is the variable input, $K$ is capital, the quasi-fixed input, and $T$ is technology. The supply price of $K$ is $q$ and it is assumed to be a function of the rate of investment and time, $q(I,t)$. All other variables ($Q$, $K$, and $v$) are functions of time. The net cash flow ($R$) of a competitive firm is

$$R(t) = p(t)\, F(K(t),v(t),T) - w(t)v(t) - q(t)[\dot{K}(t) + \delta K(t) + c(\dot{K})], \tag{20}$$

where $q(t)c(K)$ represents an internal cost of adjusting capital, $p(t)$ and $w(t)$ are the product and input prices, respectively, and $\delta$ is the rate of depreciation of $K(t)$. The nonstochastic formulation of the problem calls for selecting a time path of inputs that maximize the present value of the stream of R(t):

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[17] This section is based on Mundlak 1987b.

$$\text{Maximize} \int_0^\infty e^{-rt} R(t)\,dt, \tag{21}$$

subject to

$$\begin{aligned} &K(0) = K_0, \text{ where } K_0 \text{ is given,} \\ &I(t) = \dot{K}(t) + \delta K(t), \text{ and} \\ &\lim_{t \to \infty} [e^{-rt} R(t)] = 0. \end{aligned}$$

Given an interior solution, the first-order condition for the vector of variable inputs requires

$$\frac{\partial R(t)}{\partial v(t)} = 0, \ \frac{\partial F(\cdot)}{\partial v(t)} = \frac{w(t)}{p(t)}, \tag{22}$$

and the Euler equation is

$$\frac{\partial R(t)}{\partial K(t)} - \frac{d}{dt}\left(\frac{\partial R(t)}{\partial \dot{K}(t)}\right) = 0. \tag{23}$$

Equation (22) implies that, along the optimal path, the quantity of input employed at time t has no effect on revenues in subsequent periods and that the optimal levels of this input are determined by equating the input's marginal product to its real price in each period. Consequently, the optimization can be solved in steps. The first step is to determine the optimal level of v(t), as a function of both prices and K(t), for each period. The solution from this optimization problem is substituted into equation (20) to obtain a restricted profit function:

$$\pi(K(t), v^*(t), s(t), T),$$

where s is a vector of state variables that, in this case, contains only w and p. Note that although not explicitly indicated here, $v^*$ is also a function of K(t), T, and $\dot{s}(t)$.

Given this restricted profit function, the second stage in the optimization problem is to maximize

$$\int_0^\infty e^{-rt} \{\pi(K(t),v^*(t),s(t),T) - q(t)[\dot{K}(t) + \delta K(t) + c(\dot{K})]\}dt, \tag{24}$$

subject to the constraints of equation (21). Suppressing the dependence of the relevant functions on s and the time index, the Euler equation for this problem is

$$\frac{\partial \pi}{\partial K} - q(\delta + r - \hat{q}) - q(\hat{q} - r)c'(\dot{K}) + qc''(\dot{K})\ddot{K} = 0, \tag{25}$$

where $\hat{q} = \dot{q}/q$, $\ddot{K}$ is the first derivative of $\dot{K}$ with respect to time, and $c'$ is the first derivative of $c$. In the absence of internal costs of adjustment, that is, $c(\dot{K}) = 0$, the optimal time path of $K(t)$, say $K^*(t)$, is obtained by solving

$$\frac{\partial \pi}{\partial K} - q(\delta + r - \hat{q}) = 0, \tag{26}$$

which states that, at its optimal level, the value marginal productivity of capital is equal to the user cost, allowing for price appreciation. Since $K^*$ is a function of the prices that enter the restricted profit function, a change in prices requires an adjustment in $K^*(t)$. This formulation assumes that the adjustment in capital can be performed in one step. As it is believed that firms do not adjust their capital stock instantaneously, the concept of cost of adjustment is introduced to account for the gradual adjustment from an arbitrary $K(t)$ to the optimal level $K^*(t)$ (Gould 1968; Lucas 1967; Treadway 1969).

When dealing with the agricultural sector as a whole, and with a place such as Punjab, where agriculture constitutes an important sector of the economy, the relevant costs of adjustment are external to the sector rather than internal, as in the case of a single firm. In the case of Punjab, external costs of adjustment arise as the supply function for resources going into agriculture is upward sloping. That is, for agriculture to increase its share of total resources, it has to pay increasing prices. It is for this reason that the expected rates of return on capital in agriculture and in its alternative uses (nonagricultural) are considered important determinants of agriculture's share of total investment. This is reinforced when the farmers themselves face an upward-sloping supply function of capital.

The present analysis can be extended to accommodate the choice-of-technique framework by simply using equation (11) as the expression for $\pi$ in equation (24). In terms of the current problem, however, the first stage in the decision process, which is conditional on a given time path for the quasi-fixed inputs, for example, $K(t)$, is decomposed into two separate components—the area allocation decision and the determination of yields (see the discussion above). Thus the determination of the optimal path for the quasi-fixed inputs is the third and final stage in the optimization problem.

## Empirical Specification

Based on the foregoing discussion of the conceptual framework, the empirical model constitutes three blocks of equations. The first block consists of equations describing the allocation of area to the various techniques of production, by season. Rather than explaining the allocation of net cropped area to the various possible techniques of production, the area allocation equations describe the allocation of net irrigated (dry) cropped area among the different possible irrigated (dry) crop varieties, for each season. Thus, the first block of equations can be summarized schematically as follows:

$$A_j/I = \alpha_0 + (\text{Incentives})\,\alpha_1 + (\text{Constraints})\alpha_2 + (\text{Environment})\alpha_3 + u, \text{ and} \tag{27}$$

$$A_j/D = \alpha_0' + (\text{Incentives})\alpha_1' + (\text{Constraints})\alpha_2' + (\text{Environment})\alpha_3' + u', \tag{28}$$

where $A_j/I$ ($A_j/D$) is the share of net irrigated (dry) area allocated to technique j. As illustrated, the allocation decisions are determined by three sets of variables: incentives, constraints, and environment. The $\alpha$'s are coefficients to be estimated, and u and u′ are random disturbance terms.[18] Note that in this specification, the composition of techniques is endogenous and assumed to depend on, among other factors, the availability of resources and not vice versa as many other studies have assumed (for example, see Desai 1982, 31).

The second block of the model consists of a set of yield equations. The data include yields only by crop and not by technique, and thus constitute aggregates over techniques in the sense discussed above. Therefore, they depend on the implemented technology. Schematically, these equations can be expressed as follows:

$$\begin{aligned} Y_i = \beta_0 + (\text{Incentives})\beta_1 + (\text{Technology})\beta_2 \\ + (\text{Fertilizer})\beta_3 + (\text{Environment})\beta_4 + u. \end{aligned} \tag{29}$$

The third and final block of equations describes the changes in the quasi-fixed inputs over time. They are described as follows:

$$\begin{aligned} K(t) = \tau_0 + (\text{Incentives})\,\tau_1 + (\text{Constraints})\tau_2 \\ + (\text{Environment})\tau_3 + K(t-1)\tau_4 + u. \end{aligned} \tag{30}$$

The specific variables included in each block of equations and the results from estimation are described in Chapters 5 and 6. Although the blocks of equations are discussed separately throughout, all three blocks of equations are estimated simultaneously as a system. Given the outline of the model just presented, the three blocks of equations described form a block recursive system. As will become clearer following the more detailed discussions of the variables entering the different blocks of equations (in Chapters 5 and 6), the levels of quasi-fixed inputs (block 3) are determined solely by lagged endogenous and exogenous variables. The level of quasi-fixed inputs then enters the area allocation equations along with other predetermined variables. Finally, the area allocated to the various techniques, the level of quasi-fixed inputs, and other predetermined variables enter the yield determination equations. Given the recursive nature of this system, the system is estimated using the iterative Zellner efficient method. The omission of an equation explaining the "other crops" planted on irrigated and dry lands in both the *kharif* and *rabi* seasons eliminates the problem of the sets of area-share equations having a singular variance-covariance matrix (see the Cropping Alternatives subsection in Chapter 5). Symmetry conditions are imposed on the revenue variables within each set of area shares. Although the predicted shares from this system will not always be in the relevant range (0,1), as they would if a multinomial logit-type model were specified, the approach utilized allows us to impose symmetry restrictions on the parameters at every point in the sample. This additional information can be important in a data set plagued by multicollinearity.

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[18] A more detailed discussion of the specific formulation is left for Chapter 5.

# 5

# ESTIMATES OF THE SHORT-RUN YIELD AND AREA RESPONSES

The outline of both the yield and area relations presented in Chapter 4 is followed now by the empirical analysis. The data and variables used in the analysis and the results are discussed. The conceptual framework calls for a somewhat detailed analysis. In the case of Punjab, there are not only multiple techniques of production for each crop, but also two growing seasons and a sizable set of exogenous variables. The detailed structure of the model is unavoidable if the role of the various variables is to be revealed empirically. In addition, an understanding of the disaggregated level of results is more difficult than usual (yet rewarding) due to the possibility of variables exhibiting direct as well as indirect effects on the decisions examined. To facilitate the reading of this chapter, the results of the various stages in the decision process are summarized at the end of the appropriate sections.

## Model Specification

The data base used in this study consists of yearly aggregate district-level data covering the period 1960-79. Although the data encompass the performance of 10 out of the 12 districts of present-day Punjab, the number of cross-sectional units is 9.[19] Thus the data set consists of 180 observations (India, various years a, b, c, d; Punjab, various years d).

### Area Allocation Equations

As noted in Chapter 4, the area allocation equations describe the allocation of net irrigated (dry) cropped area among the different possible irrigated (dry) crop varieties for each season. Further, the determinants of the allocation decisions are classified into three sets of influences: incentives, constraints, and environment. Following a delineation of the cropping alternatives incorporated in this study, the specific variables that capture the effect of the incentives, constraints, and environment on the area allocation decisions are described.

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[19] A full data series is unavailable for Rupnagar for the sample period, thus this district is not included in the analysis. Changes in district boundaries during the sample period require that data describing the performance of Faridkot be incorporated into the data from Ferozepore and Bhatinda districts. Although data from Hoshiarpur are available, unresolvable inconsistencies in the values of some of the variables led to the deletion of this district from the analysis. Thus the total number of regional units included in the analysis is 9, summarizing the performance of 10 districts.

*Cropping Alternatives.* As suggested in Chapter 3, the agricultural economy of Punjab is diverse. Cropping activities still dominate the sector. The five major crops—wheat, rice, cotton (American and Desi varieties), maize, and gram—that account for 67 to 80 percent of the gross cropped area over the sample period are incorporated in this study. The various combinations of cropping activities by technique are summarized in Table 5. The "other" activities include fallow land as well as land sown to all other minor crops. The original data base delimits the area planted to dry and irrigated varieties for gram, cotton, and maize. No distinction is made between the two types of cotton, as data on the extent to which cotton is irrigated are not disaggregated by variety.

It is assumed that there are three techniques of production for wheat and rice, an irrigated MV and two traditional varieties (irrigated and dry). Information is available only on the area planted to MVs and on the total area of each crop irrigated. To disaggregate the crops by technique, it is assumed that all MVs in Punjab are irrigated (see Appendix 2 for a detailed description of the disaggregation process).

Although information regarding adoption of improved varieties for maize is available, the production of maize is only disaggregated into irrigated and dry techniques because the extent to which these improved varieties have been accepted has been relatively minor and has fluctuated considerably over time (see Chapter 3). A large part of this varied success is explained by the unreliable yields of the newer varieties and the problems some of these varieties have experienced with disease and drought. Because the data required to study the impact of these problems on the rate of adoption of the new varieties are not available in the data base, the distinction between irrigated high-yielding varieties and irrigated traditional varieties is not made.

**Table 5—Cropping alternatives in the rabi and kharif seasons**

| Season | Techniques | |
|---|---|---|
| | Irrigated | Dry |
| Rabi | Modern-variety wheat | Wheat |
| | Traditional wheat | Gram |
| | Gram | Other |
| | Other | |
| Kharif | Modern-variety rice | Rice |
| | Traditional rice | Maize |
| | Irrigated maize[a] | Cotton |
| | Cotton (American and Desi) | Other |
| | Other | |

[a] The irrigated maize category includes both improved and traditional varieties.

*Incentives.* As in the discussion in Chapter 4, the incentive measures include product and factor prices. Under uncertainty, prices are replaced by expected prices. In the spirit of the framework outlined in Chapter 4, area response to price, $\partial A_j/\partial p$, is viewed as a function of the state variables relevant to the stage 1 decision problem ($s^1$) rather than as a constant, as is usually assumed in supply response analyses. Making all such derivatives a function of all the state variables, however, introduces more interaction terms in the area equations than the data can sustain. Thus the analysis limits the dependence of $\partial A_j/\partial p$ on the state variables to a dependence on the implemented technology, the most critical variable in the study. To capture this effect, expected product prices appear as interaction terms with expected yield by variety. (The yields by variety are "expected" in the sense that the effect of random shocks, such as weather, on yield are ignored.) Thus the variables included to capture the relevant incentives for producers are expected average revenue per unit of land for each technique rather than the product price by itself.

The computation of revenue by techniques requires yields by techniques. The derivation of regional yields for the traditional varieties is described in Appendix 2. When overall crop yield, the yields of the traditional varieties, and area allocated to the different varieties are known, the yields of the MVs can be obtained as a residual. The results obtained by following this procedure show no upward trend in modern wheat yields. This finding is inconsistent with the widely held view that there was a continuous improvement in the MVs. This inconsistency can be attributed to the method of deriving the MV yields. To overcome this problem, a (lagged) three-year average of overall crop yield was used as an indirect measure. (By averaging the yields over the past three years, the effects of random disturbances such as weather are reduced. As noted above, it is in this sense that the term "expected" is used.)

To see the implication of using this overall crop yield variable, write a general expression for the share of area allocated to the MVs, $S_H(p\bar{y}, py_T, x)$, where p is the price of the crop, regardless of variety, $\bar{y}$ is a weighted average yield of the modern (H) and traditional (T) varieties, $\bar{y} = \lambda y_H + (1-\lambda)y_T$, and x represents all other variables in the share equation. The response to price is obtained by differentiating $S_H$ with respect to p. Let $S_1$ and $-S_2$ be the partial derivatives of $S_H$ with respect to the first two arguments (both derivatives are positive), and write $\partial S_H/\partial p = S_1\bar{y} - S_2y_T = \lambda S_1(y_H-y_T) + y_T(S_1-S_2)$. The result shows that the price effect on the area allocation decision depends on the difference in yields between the traditional varieties and MVs and on the degree of implementation as given by $\lambda$. The maximum impact of a change in price is achieved when the transition is completed, that is, when $\lambda = 1$.

Similarly, the effect of a change in the MV yield on its share in total area is given by $\partial S_H/\partial y_H = pS_1\partial\bar{y}/\partial y_H = pS_1\lambda$. This derivative obtains its maximum value at $\lambda = 1$, in which case it is equal to $\partial S_H/\partial\bar{y}$, which in turn is equal to the coefficient of the average yield term in the share equation. Hence, in the empirical analysis, the derivative of the MV share with respect to the average yield can be interpreted as the full impact of a change in $y_H$ on the area allocation. This explains why in the subsequent discussion $p\bar{y}$ is labeled conveniently as "average revenue of the MV."

The prices used to form the expected revenue variables are product prices deflated by wage, all lagged one year.[20] The revenue variables are deflated by wage to ensure that the area share equations are homogeneous of degree zero in all prices. In this study, the representation of incentives by average revenue is essential in order to explain the choice between different techniques that produce the same crop and consequently receive the same output price. The use of average revenue rather than price as a measure of incentives is not new in area supply response studies. In fact, Mundlak and McCorkle (1956) show that average revenue is not always superior to price in terms of explaining the data. Thus the performance of the average revenue variables should be judged separately from the framework within which it is applied.

*Constraints.* The term constraint is used here to represent the quasi-fixed inputs, both private and public, that affect the implementation of technology. The decisions on area allocation are made conditional on the available land and irrigation facilities. Data on irrigation facilities at the district level are incomplete; therefore, net irrigated area is used as a measure of the irrigation capacity available in the short run. Others have made similar assumptions in empirical studies of this region (see, for example, Schwarz 1986 and Evenson 1983). However, an important difference between the assumptions of these empirical studies and the present study exists. Each of these studies uses gross cropped area and gross irrigated area as the relevant land and irrigation constraints, respectively. Their implicit assumption is that the intensity with which the land (irrigated and dry) is cropped is exogenous. This assumption is unrealistic, and therefore this study measures the relevant land and irrigation constraints by net cropped area and net irrigated area available, respectively. Thus the intensity with which the land is cropped is determined endogenously. Further, a distinction is made between land irrigated by private sources (wells and tanks) versus government sources (canals). The reason for this distinction is twofold. First, as indicated in Chapter 3, the literature suggests that tubewell irrigation is more suitable for MVs. Second, and more important, the distinction is essential for the subsequent analysis of the response of the quasi-fixed inputs to changes in prices and technology; the private and government sectors have different rules determining their investment behavior. The net area irrigated by government and that irrigated by private sources are both included in the area equations as a proportion of net cropped area.

The MVs require considerably more fertilizer per unit of land than the traditional varieties. Consequently, their introduction caused a dramatic increase in the demand for fertilizers. Desai (1986) reports that the all-India consumption of fertilizer nutrient increased from 339,000 metric tons in 1961/62 to 1.1 million tons in 1966/67 and to 8.2 million tons in 1984/85.[21] Meeting this augmented demand required considerable resources. Initially the demand was met by imports, which were 389,000 tons in 1961/62 and then increased to 898,000 tons in 1966/67 and to 3.6 million tons in 1984/85. This shows that domestic production had to increase from meager quantities to a level of about 5.0 million tons. Such a growth of supply was gradual because of its heavy resource requirement. This in turn constrained the implementation of the MVs.

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[20] Alternative specifications of price expectations were formulated. Results were robust to the different formulations, and thus the simplest specification (one-year lag) was maintained. The wage series (India, various years a) is the average wage (by district) for all field operations (plowing, seeding, and harvesting).

[21] All tons referred to in this study are metric tons.

At the time of planting, farmers cannot know with certainty the quantities of fertilizer that will be available to them and therefore must base their planting decisions on expectations. The expected supply of fertilizers is measured by the supply available (used) last year (measured in terms of total nutrient content per net cropped area). As the data used are district level, the distribution of the overall supply to the districts may reflect demand pressures. Obviously, lagged supply values are independent of contemporaneous shocks in demand. No attempt was made to construct a more elaborate specification of expectations of fertilizer availability, as a strong response to increases in supply of fertilizers is captured well by the present procedure.

The availability of physical infrastructure, represented here by the availability of roads, has a potential influence on the area allocation decisions. Specifically, the availability of roads affects the degree to which the rural areas are integrated within the market. As annual district-level data are not available on other components of infrastructure, they are not included in the analysis. To the extent that these omitted variables are correlated with roads, they are partially represented by the road variable (kilometers of road per 1,000 hectares).

*Environment.* Environmental factors that affect the allocation decisions include the local agronomic and climatic conditions in the particular districts. These variables are difficult to quantify; therefore, fixed district effects are introduced. One environmental variable that is easy to quantify and on which data are available is rainfall. Thus, rainfall variables are incorporated to capture the importance of preplanting rain on the area allocation decisions. (For a discussion of the importance of rain in the decisions of the producers in Punjab see Herdt 1972.) Because the district effects will pick up the differences in mean rainfall across districts, the rainfall variables will capture the importance of the transitory, or random intraregional, intertemporal, component.

In addition to the fixed district effects, a pre-green revolution intercept shifter is included to allow the optimal mean shares of area allocated to the different varieties to change following the introduction of the MVs.

### Yield Equations

Because yields are available only by crop and not by variety (technique), the dependent variables in the yield equations are overall yield by crop. Thus the overall crop yield depends on (among other factors) the composition of techniques chosen to produce each particular crop. The composition itself is endogenous within the system, but it is independent of the outcome of the current yields, so it is predetermined and not correlated with the disturbances of the yield equations. The relevant technology variables for wheat and rice include the proportion of wheat and rice area planted to MVs. The proportions of wheat and rice area sown with the irrigated traditional varieties are not included, as these variables are highly (negatively) correlated with the MV variables. For gram, maize, and cotton, the composition of implemented techniques is captured by the inclusion of the proportion of each particular crop area that is irrigated. Because overall cotton yield also depends on the allocation of total cotton area planted to the American and Desi varieties, the proportion of cotton area planted to American cotton—the more productive of the two varieties—is also included.

The constraint included in the yield equations is the amount of fertilizer available per cropped hectare. As there was excess demand for fertilizers, it is assumed that the quantity used was equal to the supply. Unlike the planting decisions that have to be made conditional on expectations, yields are affected by the actual quantities applied. Consequently, current values of fertilizers per net cropped area are used in the yield equations. The influences of the environment are captured by allowing for fixed district effects and by including a set of variables that measure the amount of rainfall during the critical months of the growing period for each of the crops.[22] Interaction terms are introduced to allow the yield response to rainfall and fertilizer to vary with the implemented technology. Initially, expected prices were included in the yield equations, but their direct effect on yields was not empirically significant. The issue of the insignificant direct effect of prices on yield versus their indirect effect on yield is discussed below.

## The Area Allocation Decisions

### Results: Area Allocation Equations

The variables used in the area share equations appear in Table 6 and the results are given in Tables 7-9. The results are examined by season. It is important to note that all the results from the area share equations describe the response of technique composition to changes in incentives and constraints (intertechnique effect). Thus the substitutability and complementarity found between techniques reflect all of these factors and not simply agrotechnical considerations. Highlighting the consistent structure underlying the results causes the discussion to become somewhat detailed.[23] The reader who is not interested in the details can proceed to the summary sections below.

Initially, low Durbin-Watson statistics in the *kharif* irrigated and dry share equations indicated that positive first-order autocorrelation was a problem.[24] To correct for the problem, each equation of the *kharif* area model was estimated by ordinary least squares. Following Parks (1967), the residuals from each of these equations were used to derive estimates of the first-order autocorrelation coefficient for each district. Data for each of these equations were then transformed as follows:

$$Y^*_{it} = Y_{it} - \rho_i Y_{it-1} \text{ and } X^*_{it} = X_{it} - \rho_i X_{it-1},$$

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[22] For a description of the specific rainfall variables, see Table 15.

[23] To keep the length of the discussion manageable, the results for the "other" shares deleted for estimation purposes are not presented or discussed.

[24] Although not directly interpretable for cross-section times-series models such as this, the particularly low Durbin-Watson statistics (less than one) indicated an autocorrelation problem.

## Table 6—Definition of variables: area equations

| Variable | Definition | Equation(s) |
|---|---|---|
| Expected revenues[a] | | |
| MV RICE | Modern-variety rice | Irrigated *kharif* shares |
| IRRIGATED RICE | Irrigated traditional rice | Irrigated *kharif* shares |
| IRRIGATED MAIZE | Irrigated maize | Irrigated *kharif* shares |
| IRRIGATED COTTON | Irrigated cotton | Irrigated *kharif* shares |
| DRY RICE | Dry traditional rice | Dry *kharif* shares |
| DRY MAIZE | Dry traditional maize | Dry *kharif* shares |
| DRY COTTON | Dry cotton | Dry *kharif* shares |
| MV WHEAT | Modern-variety wheat | Irrigated *rabi* shares |
| IRRIGATED WHEAT | Irrigated traditional wheat | Irrigated *rabi* shares |
| IRRIGATED GRAM | Irrigated gram | Irrigated *rabi* shares |
| DRY WHEAT | Dry traditional wheat | Dry *rabi* shares |
| DRY GRAM | Dry gram | Dry *rabi* shares |
| Constraints | | |
| GOVERNMENT IRRIGATION | Net irrigated area, government canals[b] | All equations |
| PRIVATE IRRIGATION | Net irrigated area, private sources[b] | All equations |
| E FERTILIZER | Expectation of fertilizer available[c] | All equations |
| ROADS | Kilometers of road available per hectare | All equations |
| Environment | | |
| JS | Preplanting rain (0.01 mm) June-September | All *rabi* equations |
| MAY | Preplanting rain (0.01 mm) May | Rice and maize equations |
| JUN | Preplanting rain (0.01 mm) June | Rice and maize equations |
| JF | Preplanting rain (0.01 mm) January-February | Cotton equations |
| DISTRICT | A dummy variable is introduced for each district[d] | All equations |
| PRE-INT | Intercept shifter: 1960-65 | All equations |

[a] All expected revenue variables (Rs/1,000 hectares) are deflated by wage (Rs/8-hour day).

[b] Both irrigation variables are deflated by net cropped area and thus measure the proportion of land irrigated by source.

[c] The expectation is captured by kilograms of fertilizer (nutrient) available per net cropped area (1,000 hectares) in the previous cropping year.

[d] The districts are listed in Tables 7, 8, and 9.

where $\rho_i$ is the estimated first-order autocorrelation coefficient for district i, $Y_{it}$ is the dependent variable for district i in time t, and $X_{it}$ is the vector of independent variables for district i in time t. The transformed variables $Y^*_{it}$ and $X^*_{it}$ were then used in the *kharif* area share equations when the whole system was estimated.[25]

*Rabi Season—Irrigated Area Shares.* All coefficients on the own expected revenue variables are positive and significant.[26] The only significant competition for irrigated area, as indicated by a negative cross-revenue coefficient, is between MV and irrigated traditional wheat. Because the price of wheat is the same for the two varieties, the competition between these varieties reflects the differences in

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[25] The first observation (t = 1960) for each cross-section was omitted from the full model because of these corrections in the *kharif* area share equations.

[26] The significance of the variables in each of these equations is judged by the size of the estimated coefficients relative to their standard errors. The discussion refers to coefficients with more than twice their standard errors as "significant."

## Table 7— Estimates of irrigated and dry area allocation equations, rabi season

| | Dependent Variable | | | | |
|---|---|---|---|---|---|
| | Irrigated Shares | | | Dry Shares | |
| Explanatory Variable | Modern-Variety Wheat | Traditional Wheat | Gram | Wheat | Gram |
| Expected revenues | | | | | |
| MV WHEAT | 0.00123 | -0.00089 | -0.00005 | ... | ... |
| | (6.15) | (-6.20) | (-1.12) | | |
| IRRIGATED WHEAT | -0.00089 | 0.00041 | -0.00008 | ... | ... |
| | (-6.20) | (2.81) | (-1.59) | | |
| IRRIGATED GRAM | -0.00005 | -0.00008 | 0.00013 | ... | ... |
| | (-1.12) | (-1.59) | (2.51) | | |
| DRY WHEAT | ... | ... | ... | -0.00077 | 0.00009 |
| | | | | (-3.04) | (0.53) |
| DRY GRAM | ... | ... | ... | 0.00009 | -0.00084 |
| | | | | (0.53) | (-4.08) |
| Constraints | | | | | |
| PRIVATE IRRIGATION | 0.74701 | -0.73056 | -0.25374 | 0.12686 | -0.05379 |
| | (6.24) | (-8.59) | (-9.51) | (1.68) | (-0.49) |
| GOVERNMENT IRRIGATION | 0.23259 | -0.17860 | -0.10068 | 0.88662 | 0.02292 |
| | (1.55) | (-1.63) | (-2.84) | (7.28) | (0.13) |
| E FERTILIZER | 0.00125 | -0.00090 | 0.00015 | -0.00177 | -0.00120 |
| | (3.3) | (-3.08) | (-1.84) | (-4.57) | (-2.20) |
| ROADS | 0.02376 | -0.00590 | 0.00236 | -0.00272 | 0.02521 |
| | (2.35) | (-0.75) | (1.06) | (-0.33) | (2.15) |
| Environment | | | | | |
| JS | 0.00123 | -0.00095 | 0.0000003 | 0.000749 | 0.00067 |
| | (3.16) | (-3.30) | (0.00) | (2.58) | (1.66) |
| GURDASPUR | -0.05227 | -0.17313 | -0.06371 | 0.32692 | -0.08286 |
| | (-1.04) | (-4.28) | (-5.40) | (10.67) | (-1.87) |
| AMRITSAR | -0.15295 | -0.07346 | 0.01367 | 0.05845 | -0.04848 |
| | (-2.29) | (-1.43) | (0.87) | (0.77) | (-0.45) |
| KAPURTHALA | -0.27515 | 0.06405 | 0.02425 | 0.24449 | -0.13994 |
| | (-4.21) | (1.2) | (1.62) | (3.94) | (-1.59) |
| JULLUNDUR | -0.21511 | 0.13741 | 0.03074 | 0.15024 | -0.05307 |
| | (-5.19) | (4.04) | (3.26) | (4.35) | (-1.08) |
| FEROZEPORE | 0.10528 | -0.29953 | -0.02341 | -0.26142 | 0.0924 |
| | (1.62) | (-5.9) | (-1.55) | (-4.81) | (1.20) |
| LUDHIANA | -0.14953 | 0.16194 | 0.03757 | -0.01825 | -0.07843 |
| | (-3.71) | (4.96) | (4.09) | (-0.77) | (-2.34) |
| BHATINDA | 0.09541 | -0.32858 | 0.00056 | -0.50382 | 0.30486 |
| | (1.37) | (-6.04) | (0.03) | (-9.13) | (3.96) |
| SANGRUR | 0.02996 | -0.0954 | 0.03375 | -0.28784 | 0.08314 |
| | (0.71) | (-2.77) | (3.53) | (-8.14) | (1.77) |
| INTERCEPT | -0.22755 | 0.90415 | 0.18991 | -0.00076 | 0.00009 |
| | (-3.03) | (15.38) | (9.68) | (-3.04) | (0.53) |
| PRE-INT | ... | 0.82333 | 0.20667 | ... | ... |
| | | (14.91) | (10.84) | | |
| $R^2$ | 0.949 | 0.8097 | 0.8811 | 0.9261 | 0.9351 |

Notes: The numbers in parentheses are t-statistics. See Table 6 for definitions of variables.

## Table 8—Estimates of irrigated area allocation equations, kharif season

| Explanatory Variable | Dependent Variable: Irrigated Shares<br>Modern-Variety Rice | <br>Traditional Rice | <br>Maize | <br>Cotton |
|---|---|---|---|---|
| Expected revenues | | | | |
| MV RICE | 0.00020<br>(3.36) | −0.00012<br>(−2.80) | −0.00004<br>(−1.24) | 0.00008<br>(3.35) |
| IRRIGATED RICE | −0.00012<br>(−2.80) | 0.00011<br>(1.64) | 0.00001<br>(0.2) | −0.00002<br>(−0.89) |
| IRRIGATED MAIZE | −0.00004<br>(−1.24) | 0.00001<br>(0.2) | 0.00015<br>(3.7) | −0.00003<br>(−1.97) |
| IRRIGATED COTTON | 0.000085<br>(3.35) | −0.00002<br>(−0.89) | −0.00003<br>(−1.97) | 0.00005<br>(2.3) |
| Constraints | | | | |
| PRIVATE IRRIGATION | −0.17733<br>(−3.06) | 0.03924<br>(0.91) | −0.02241<br>(−0.63) | −0.18747<br>(−4.34) |
| GOVERNMENT IRRIGATION | −0.11958<br>(−1.79) | −0.13078<br>(−2.69) | 0.16236<br>(4.36) | −0.50589<br>(-10.18) |
| E FERTILIZER | 0.00053<br>(3.55) | 0.00018<br>(1.49) | −0.00002<br>(−0.28) | −0.00025<br>(−2.14) |
| ROADS | 0.05195<br>(11.16) | −0.01477<br>(−3.69) | −0.01238<br>(−3.96) | 0.01932<br>(5.03) |
| Environment | | | | |
| MAY | −0.00083<br>(−1.00) | 0.00014<br>(0.23) | 0.00091<br>(1.74) | . . . |
| JUN | −0.00051<br>(−1.13) | 0.00093<br>(2.64) | 0.00011<br>(0.35) | . . . |
| JF | . . . | . . . | . . . | −0.00286<br>(−5.71) |
| GURDASPUR | −0.02332<br>(−0.39) | 0.10256<br>(1.29) | −0.05467<br>(−2.88) | 0.005565<br>(0.15) |
| AMRITSAR | −0.05293<br>(−1.33) | 0.08609<br>(3.07) | −0.07677<br>(−3.37) | 0.19235<br>(4.68) |
| KAPURTHALA | −0.01428<br>(−0.32) | −0.02592<br>(−0.80) | 0.03263<br>(1.04) | −0.02636<br>(−0.76) |
| JULLUNDUR | −0.21858<br>(−7.13) | −0.02243<br>(−0.30) | 0.18408<br>(9.06) | −0.03697<br>(−0.94) |
| FEROZEPORE | −0.09714<br>(−2.50) | −0.002709<br>(0.10) | −0.13594<br>(−5.61) | 0.41264<br>(2.04) |
| LUDHIANA | −0.22896<br>(−5.72) | −0.05275<br>(−0.42) | 0.2195<br>(10.70) | 0.06424<br>(10.80) |
| BHATINDA | −0.34964<br>(−3.06) | 0.0633<br>(0.76) | −0.16399<br>(−6.38) | 0.61421<br>(10.80) |
| SANGRUR | −0.15378<br>(−4.86) | −0.04143<br>(−1.47) | 0.02239<br>(1.08) | 0.23828<br>(6.81) |
| INTERCEPT | 0.09843<br>(2.23) | 0.12779<br>(4.13) | 0.14708<br>(5.20) | 0.13102<br>(3.23) |
| PRE-INT | . . . | 0.18413<br>(6.19) | 0.10684<br>(3.91) | 0.15831<br>(4.08) |
| $R^2$ | 0.9621 | 0.8759 | 0.9462 | 0.989 |

Notes: The numbers in parentheses are t-statistics. See Table 6 for definitions of variables.

## Table 9—Estimates of dry area allocation equations: kharif season

| Explanatory Variable | Dependent Variable: Dry Shares<br>Rice | <br>Maize | <br>Cotton |
|---|---|---|---|
| Expected revenues | | | |
| DRY RICE | 0.00021<br>(3.79) | 0.00003<br>(0.97) | 0.00004<br>(2.05) |
| DRY MAIZE | 0.00003<br>(0.97) | -0.00001<br>(-0.21) | 0.00004<br>(-2.82) |
| DRY COTTON | 0.00004<br>(2.05) | -0.00004<br>(-2.82) | 0.00003<br>(1.99) |
| Constraints | | | |
| PRIVATE IRRIGATION | 0.04272<br>(1.68) | 0.04301<br>(1.29) | 0.00111<br>(0.13) |
| GOVERNMENT IRRIGATION | -0.00294<br>(-0.09) | 0.04549<br>(1.14) | 0.03319<br>(2.16) |
| E FERTILIZER | 0.00010<br>(0.96) | -0.00065<br>(-4.26) | -0.00006<br>(-1.21) |
| ROADS | -0.00097<br>(-0.45) | 0.0212<br>(5.9) | 0.00009<br>(0.07) |
| Environment | | | |
| MAY | -0.00007<br>(-0.14) | -0.00017<br>(-0.29) | . . . |
| JUN | 0.00067<br>(2.49) | 0.00042<br>(1.23) | . . . |
| JF | . . . | . . . | -0.00060<br>(-3.65) |
| GURDASPUR | 1.02995<br>(1.34) | 0.06954<br>(4.62) | 0.00145<br>(0.19) |
| AMRITSAR | -0.03020<br>(-1.47) | -0.04115<br>(-1.21) | -0.00737<br>(-0.83) |
| KAPURTHALA | -0.05619<br>(-1.47) | -0.05283<br>(-1.21) | -0.00202<br>(-0.84) |
| JULLUNDUR | -0.06503<br>(-3.96) | 0.03269<br>(2.46) | -0.00368<br>(-0.84) |
| FEROZEPORE | -0.04859<br>(-3.04) | -0.07296<br>(-3.28) | -0.01119<br>(-1.64) |
| LUDHIANA | -0.06235<br>(-10.74) | -0.03627<br>(-1.85) | -0.00069<br>(-0.15) |
| BHATINDA | -0.04600<br>(-2.71) | -0.11088<br>(-2.05) | -0.00558<br>(-0.81) |
| SANGRUR | -0.05609<br>(-4.64) | -0.08985<br>(-6.50) | -0.00143<br>(-0.32) |
| INTERCEPT | 0.01851<br>(1.75) | 0.03808<br>(2.33) | 0.00376<br>(0.72) |
| $R^2$ | 0.9058 | 0.9103 | 0.6815 |

Notes: The numbers in parentheses are t-statistics. See Table 6 for definitions of variables.

yields. The higher yields of MV wheat result in an increase in its share at the expense of the traditional variety as the price of wheat increases.

The results suggest that the constraints are very important in the area allocation decisions. The importance of the constraints in determining the pace of transition from the traditional to MV wheat is reflected by the positive and significant coefficients of the constraints in the MV wheat equation and the negative and significant coefficients of the same variables in the irrigated traditional wheat equation. Specifically, the transition to MV wheat is influenced positively by an increase in fertilizer and irrigated area. The larger and more significant coefficient on the private irrigation variable in the MV wheat equation indicates that the availability of private irrigation is more conducive to the adoption of MV wheat than the availability of government irrigation. As more irrigated area and fertilizer became available, area allocated to MV wheat increased at the expense of gram. The availability of roads encouraged the transformation to MV wheat, and the monsoon rains favor MV wheat over the traditional varieties. For the most part, the district effects are significant, reflecting the importance of the local environmental conditions on the planting decisions.

*Rabi Season—Dry Area Shares.* The coefficients on the own-revenue variables are negative and significant. Since the expected yields of traditional dry wheat and gram are constant over the period of study, the changes in the expected revenues of these techniques reflect movement in prices. Consequently, the negative coefficients indicate that an increase in price reduces the shares of the dry land allocated to these varieties. Recall from the irrigated share results that higher wheat and gram prices, and therefore revenues, increased production of these crops on irrigated area. Thus, irrigated varieties of wheat and gram are substitutes for the dry varieties. Further, the availability of fertilizer encourages the shift from dry to irrigated varieties. To a large extent, the competition between the irrigated and dry varieties as prices and the availability of fertilizers change may reflect the fact that during the *rabi* season land is being cultivated as intensively as possible given the resources available.

An increase in irrigated area, particularly area irrigated by canals, has a positive effect on area allocated to dry wheat. This finding may be capturing the effect of the crop rotation practice of growing dry wheat on area irrigated in the previous season (and therefore categorized as irrigated area rather than dry cropped area).

*Kharif Season—Irrigated Area Shares.* All own-revenue coefficients are positive and, with the exception of traditional rice, also significant. The only significant revenue competition is between MV and irrigated traditional rice and irrigated cotton and maize. As in the case of wheat, the common price for MV and irrigated traditional rice indicates that the revenue competition exhibited by these varieties reflects their different yields. The higher yield for MV rice increases its share in irrigated area. In addition, there is another significant cross-revenue effect—irrigated cotton appears to be a complement to MV rice.

With the exception of the coefficient on government irrigation in the maize equation, all of the significant coefficients on the two irrigated area variables are negative. This shows clearly that expansion of irrigated area favored the *rabi* season crops at the expense of the *kharif* season crops.

An increase in the availability of fertilizer increased the area allocated to both the MV and the traditional varieties of rice. This finding is consistent with the fact that rice is fertilizer-intensive. In contrast to rice, fertilizer availability has a negative and significant effect on area allocated to irrigated cotton and a neutral influence on area allocated to irrigated maize. MV rice and cotton seem to have benefited the most from the expansion of roads.

Apparently, the preplanting rainfall is positively associated with the traditional rather than the MV rice. It also has a positive influence on maize area and a negative effect on cotton area.

*Kharif Season—Dry Area Shares.* Two out of the three own-revenue coefficients are positive and significant. This finding is in marked contrast to the *rabi* dry share results where all own-revenue coefficients were negative and significant. The crops analyzed constitute only a small fraction of the dry area in the *kharif* season and, consequently, there is more potential for their expansion in response to higher prices.

An increase in area irrigated by tubewells has a favorable effect on all three dry crops. This is similar to the result for dry wheat in the *rabi* season and may be capturing the effect of the rotation practice of growing dry crops on land irrigated in the previous season.

As in the irrigated share equations, as more fertilizer becomes available, the proportion of land allocated to maize and cotton decreases. Rain is not particularly important in the area allocation decisions in the dry season. The one exception to this finding is June rainfall in the rice equation.

To help summarize the discussion so far, Tables 10 and 11 highlight the qualitative intertechnique effects of the variables in the area share equations whose coefficients are larger than their standard error (in absolute value). The quantitative importance of these intertechnique effects are summarized below in the form of area elasticities.

Table 10—Qualitative area allocation results, rabi season

| | Irrigated | | | Dry | |
|---|---|---|---|---|---|
| Variable | Modern-Variety Wheat | Traditional Wheat | Gram | Wheat | Gram |
| Constraints | | | | | |
| PRIVATE IRRIGATION | + | – | – | + | 0 |
| GOVERNMENT IRRIGATION | + | – | – | + | 0 |
| E FERTILIZER | + | – | – | – | – |
| ROADS | + | 0 | + | 0 | + |
| Expected revenues | | | | | |
| MV WHEAT | + | – | – | . . . | . . . |
| IRRIGATED WHEAT | – | + | – | . . . | . . . |
| IRRIGATED GRAM | – | – | + | . . . | . . . |
| DRY WHEAT | . . . | . . . | . . . | – | 0 |
| DRY GRAM | . . . | . . . | . . . | 0 | – |

Notes: All coefficients with t-statistics less than |1.0| are assumed to be not significantly different from zero. See Table 6 for definitions of variables.

## Table 11—Qualitative area allocation results, kharif season

| | Irrigated | | | | Dry | | |
|---|---|---|---|---|---|---|---|
| Variable | Modern-Variety Rice | Traditional Rice | Maize | Cotton | Rice | Maize | Cotton |
| Constraints | | | | | | | |
| PRIVATE IRRIGATION | – | 0 | 0 | – | + | + | 0 |
| GOVERNMENT IRRIGATION | – | – | + | – | 0 | + | + |
| E FERTILIZER | + | + | 0 | – | 0 | – | 0 |
| ROADS | + | – | – | + | 0 | + | 0 |
| Expected revenues | | | | | | | |
| MV RICE | + | – | – | + | . . . | . . . | . . . |
| IRRIGATED RICE | – | + | 0 | 0 | . . . | . . . | . . . |
| IRRIGATED MAIZE | – | 0 | + | – | . . . | . . . | . . . |
| IRRIGATED COTTON | + | 0 | – | + | . . . | . . . | . . . |
| DRY RICE | . . . | . . . | . . . | . . . | + | 0 | + |
| DRY MAIZE | . . . | . . . | . . . | . . . | 0 | 0 | – |
| DRY COTTON | . . . | . . . | . . . | . . . | + | – | + |

Notes: All coefficients with t-statistics less than |1.0| are assumed to be not significantly different from zero. See Table 6 for definitions of variables.

## Area Elasticities by Technique

The foregoing discussion dealt with shares of the various crops on either irrigated or dry area. Now the area response in terms of elasticities will be calculated. Elasticities are calculated by first simulating the model with all exogenous right-hand variables (state variables) fixed at their sample levels to establish base-run results. Then, to evaluate the effect of a 1 percent increase in the price of wheat, for example, the sample values of the price of wheat are increased by 1 percent for all years and districts, and the model is simulated again. The elasticities calculated reflect differences in the mean area of each crop and variety over the sample period between this later simulation and the base run. Because the quasi-fixed inputs are fixed at their sample values, the elasticities calculated are considered short run.

The response of the system to a shock in a state variable depends on the level of implemented technology. The area response becomes stronger in absolute value as the productivity of the implemented techniques increases. Consequently, the elasticities vary over time. To avoid reporting too many results, the examination of the time path of the responses is postponed until the section dealing with output. The following discussion concentrates on the effect of particular changes in state variables on technique choice and on the implied relative importance of the various state variables. This can be done by examining the average elasticities for the period as a whole. The average results for the period are summarized in Tables 12-14.

The conditional, or short-run, own-price elasticities of the area allocated to the superior varieties are all positive, ranging from 0.045 for irrigated cotton to 0.35 for MV wheat. (The superior varieties are wheat and rice MVs and irrigated gram, maize, and cotton.) There is pronounced price competition between MV and traditional wheat, irrigated and dry. In the case of rice, the MVs compete with the irrigated traditional varieties but are complementary to the dry varieties. Again, the

### Table 12 — Average short-run area elasticities, rabi season

| | Wheat Crop Area | | | | Gram Crop Area | | |
|---|---|---|---|---|---|---|---|
| Variable[a] | Modern Variety | Irrigated Traditional | Dry | Total | Irrigated | Dry | Total |
| Expected prices | | | | | | | |
| WHEAT | 0.349 | -1.978 | -0.268 | -0.033 | -0.470 | 0.028 | -0.147 |
| GRAM | -0.010 | -0.101 | -0.035 | -0.011 | 0.285 | -0.279 | -0.079 |
| Expected yields | | | | | | | |
| MV WHEAT | 0.672 | -2.700 | . . . | 0.142 | -0.218 | . . . | -0.077 |
| IRRIGATED GRAM | -0.010 | -0.101 | . . . | -0.016 | 0.286 | . . . | 0.101 |
| Constraints | | | | | | | |
| IRRIGATION[b] | | | | | | | |
| PRIVATE | 1.169 | -2.524 | -1.593 | 0.306 | -1.497 | -1.232 | -1.323 |
| GOVERNMENT | 0.601 | -0.414 | -0.574 | 0.349 | -0.196 | -1.792 | -1.224 |
| AREA[c] | | | | | | | |
| PRIVATE IRRIGATION | 0.746 | -0.554 | -0.032 | 0.415 | -0.281 | 0.055 | -0.065 |
| GOVERNMENT IRRIGATION | 0.319 | 1.571 | 0.710 | 0.470 | 0.878 | 0.098 | 0.372 |
| DRY | -0.202 | 0.938 | 0.707 | 0.106 | 0.589 | 1.063 | 0.897 |
| E FERTILIZER | 0.137 | -0.822 | -0.390 | 0.009 | -0.186 | -0.216 | -0.206 |
| ROADS | 0.162 | -0.304 | -0.039 | 0.069 | 0.176 | 0.302 | 0.257 |

Notes: Elasticities are calculated by simulating the model (with fixed quasi-fixed inputs) with the appropriate changes (for example, wheat price = wheat price × 1.01) and comparing results with the base run predictions. Elasticities reflect average changes in the area for Punjab over the sample period from the base run.

[a] See Table 6 for definitions of variables.

[b] The expansion in irrigated area occurs through a conversion of dry land to irrigated land.

[c] The expansion in net cropped AREA is analyzed under three different assumptions: the expansion occurs through an increase in PRIVATEly irrigated lands, the expansion occurs through an increase in land irrigated by the GOVERNMENT, and the expansion occurs through increase in net DRY area.

differences between the wheat and rice results may reflect differences in the intensity with which land is cultivated in the two seasons.

A strong positive area response with respect to expected yields is observed for the superior varieties. An increase in yields of the MV wheat and rice favors them at the expense of the traditional varieties. In the cases where only one technique exists for the production of a given crop, the elasticities with respect to yield and price are identical. This is not the case for MV wheat and rice where the two diverge, because the composition of techniques changes in response to the shock under consideration. In terms of the current formulation, it can be shown that the elasticity of $S_H$ with respect to price is equal to the sum of the elasticities with respect to $y_H$ and with respect to $y_T$. The latter is negative and therefore the elasticity with respect to $y_H$ is larger than the price elasticity.[27] Holding total area constant, this result also applies to area rather than share. As expected, the area responses with respect to expected yields of MV wheat and rice are considerably larger than those with respect to price.

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[27] In accordance wih the discussion on p. 59, terms are rearranged as shown below:

$$\frac{\partial S_H/S_H}{\partial p/p} = p\,\lambda\, S_1 y_H/S_H + p[(1-\lambda)S_1 - S_2]y_T/S_H = \frac{\partial S_H/S_H}{\partial y_H/y_H} + \frac{\partial S_H/S_H}{\partial y_T/y_T}.$$

## Table 13 — Average short-run rice area elasticities

| Variable[a] | Rice Area |  |  |  |
|---|---|---|---|---|
|  | Modern Variety | Irrigated Traditional | Dry | Total |
| Expected prices |  |  |  |  |
| RICE | 0.188 | -0.193 | 0.261 | 0.068 |
| MAIZE | -0.039 | 0.015 | 0.054 | -0.006 |
| COTTON | 0.130 | -0.056 | 0.117 | 0.046 |
| Expected yields |  |  |  |  |
| MV RICE | 0.294 | -0.363 | . . . | 0.031 |
| IRRIGATED MAIZE | -0.039 | 0.015 | . . . | -0.012 |
| IRRIGATED COTTON | 0.130 | -0.056 | . . . | 0.037 |
| Constraints |  |  |  |  |
| IRRIGATION[b] |  |  |  |  |
| PRIVATE | 0.098 | 0.697 | -1.039 | 0.276 |
| GOVERNMENT | 0.094 | -0.311 | -0.678 | 0.002 |
| AREA[c] |  |  |  |  |
| PRIVATE IRRIGATION | 0.336 | 0.696 | 0.109 | 0.434 |
| GOVERNMENT IRRIGATION | 0.326 | -0.120 | -0.111 | 0.175 |
| DRY | 0.126 | 0.020 | 0.539 | 0.091 |
| E FERTILIZER | 0.211 | 0.208 | 0.123 | 0.151 |
| ROADS | 1.268 | -0.926 | -0.068 | 0.405 |

Notes: Elasticities are calculated by simulating the model (with fixed quasi-fixed inputs) with the appropriate changes (for example, rice price = rice price × 1.01) and comparing results with the base-run predictions. Elasticities reflect average changes in the area for Punjab over the sample period from the base run.

[a] See Table 6 for definitions of variables.

[b] The expansion in irrigated area occurs through a conversion of dry land to irrigated land.

[c] The expansion in net cropped AREA is analyzed under three different assumptions: the expansion occurs through an increase in PRIVATEly irrigated lands, the expansion occurs through an increase in land irrigated by the GOVERNMENT, and the expansion occurs through increase in net DRY area.

The area elasticities with respect to the various constraints are also summarized in Tables 12-14. The area elasticities with respect to an increase in both private and government irrigation through the conversion of dry cropped area indicate that the competition among the irrigated and dry varieties varies by crop.[28] In the *rabi* season, area allocated to MV wheat increases at the expense of all the other irrigated and dry varieties as the availability of privately irrigated land increases. These elasticities are all large in absolute value, indicating a substantial change in the composition of techniques. The negative elasticities for the dry varieties with respect to irrigated area are consistent with, and thus supplement, the earlier finding that the *rabi* irrigated varieties are substitutes for the *rabi* dry varieties. The relative magnitude of the MV wheat area elasticities with respect to private and government irrigated areas is consistent with the contention in the literature that tubewells (private) are more conducive to the adoption of MV wheat than are government canals.

In terms of the *kharif* crops, all varieties of cotton are losers as dry area is converted to private or government irrigated lands. Irrigated maize and MV rice

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[28] Later in this discussion, area response to an increase in irrigated area brought about by bringing new land into production is also analyzed.

## Table 14 — Average short-run maize and cotton area elasticities

| Variable[a] | Maize Area |  |  | Cotton Area |  |  |
|---|---|---|---|---|---|---|
|  | Irrigated | Dry | Total | Irrigated | Dry | Total |
| Expected prices |  |  |  |  |  |  |
| RICE | −0.042 | 0.025 | −0.032 | 0.048 | 0.274 | 0.054 |
| MAIZE | 0.160 | −0.010 | 0.133 | −0.020 | −0.406 | −0.028 |
| COTTON | −0.055 | −0.062 | −0.056 | 0.045 | 0.446 | 0.053 |
| Expected yields |  |  |  |  |  |  |
| MV RICE | −0.049 | . . . | −0.042 | 0.059 | . . . | 0.058 |
| IRRIGATED MAIZE | 0.160 | . . . | 0.135 | −0.020 | . . . | −0.020 |
| IRRIGATED COTTON | −0.055 | . . . | −0.047 | 0.045 | . . . | 0.044 |
| Constraints |  |  |  |  |  |  |
| IRRIGATION[b] |  |  |  |  |  |  |
| PRIVATE | 0.564 | −1.754 | 0.216 | −0.016 | −1.124 | −0.033 |
| GOVERNMENT | 0.748 | −0.754 | 0.516 | −0.302 | −0.722 | −0.306 |
| AREA[c] |  |  |  |  |  |  |
| PRIVATE IRRIGATION | 0.477 | 0.244 | 0.436 | 0.414 | −0.156 | 0.405 |
| GOVERNMENT IRRIGATION | 0.546 | 0.151 | 0.481 | 0.198 | 0.714 | 0.207 |
| DRY | −0.086 | 0.963 | 0.080 | 0.237 | 0.715 | 0.246 |
| E FERTILIZER | −0.013 | −0.411 | −0.069 | −0.065 | −0.312 | −0.068 |
| ROADS | −0.363 | 0.885 | −0.175 | 0.302 | 0.026 | 0.298 |

Notes: Elasticities are calculated by simulating the model (with fixed quasi-fixed inputs) with the appropriate changes (for example, rice price = rice price × 1.01) and comparing results with the base-run predictions. Elasticities reflect average changes in the area for Punjab over the sample period from the base run.

[a] See Table 6 for definitions of variables.

[b] The expansion in irrigated area occurs through a conversion of dry land to irrigated land.

[c] The expansion in net cropped AREA is analyzed under three different assumptions: the expansion occurs through an increase in PRIVATEly irrigated lands, the expansion occurs through an increase in land irrigated by the GOVERNMENT, and the expansion occurs through increase in net DRY area.

both benefit, while the dry varieties of both these crops are adversely affected. Area allocated to irrigated traditional rice increases if the dry land is converted to well irrigation, but decreases if the land is irrigated by government canals. Irrigated traditional rice has a larger positive elasticity with respect to an increase in private irrigation than does MV rice. This finding is explained by the competition between MV wheat and MV rice for these resources described earlier. These same findings are not seen when the land is converted to canal irrigation, as MV wheat does not have as much of a distinct advantage over the other varieties on these lands.

The responses to a change in net cropped area are examined under three different scenarios: the additional area is irrigated privately, the additional area is irrigated by government canals, and the additional area is not irrigated. When the increase in net cropped area occurs through an increase in net dry area, the area allocated to all varieties increases, with the exception of MV wheat and irrigated maize. An expansion in cropped area through an increase in area irrigated by government canals increases area allocated to all crop varieties except irrigated traditional and dry rice. On the other hand, if the increase in net cropped area comes in the form of more land irrigated by tubewells, area allocated to dry cotton, irrigated and dry wheat, and irrigated gram decreases. The adverse effect of an expansion in private irrigation on more varieties when compared with a similar expansion in government irrigation can be explained by the bias of private irrigation toward the adoption of MV wheat.

An increase in the availability of fertilizer has a positive effect on all varieties of rice, which again reflects the fertilizer intensity of rice. As expected, MV rice benefits the most. The increase in rice area as more fertilizer becomes available occurs at the expense of all the other *kharif* varieties. In the *rabi* season, MV wheat competes for land with irrigated traditional and dry wheat and irrigated gram as more fertilizer becomes available. Further, the availability of roads is positively related to the rate of transformation from the traditional varieties to the MVs of rice and wheat.

### Summary of Area Allocation Decisions

At this point, it is useful to summarize the discussion of the area allocation results. First, and foremost, the results suggest that changes in the availability of quasi-fixed inputs have very significant intertechnique effects. In particular, the area elasticities indicate that the pace of transition to the MVs of both wheat and rice is positively influenced by the availability of all the quasi-fixed inputs. Second, given fixed levels of the quasi-fixed inputs, it is clear that changes in incentives lead to important changes in the composition of techniques. However, the magnitude of the area elasticities suggests that the intertechnique effects due to changes in the availability of quasi-fixed inputs are often severalfold larger than the same effects due to changes in the incentives (in absolute value).

Somewhat more specifically, the area elasticities indicate that all the own-price elasticities for the superior varieties of each crop are positive and fairly inelastic. Similarly, the area responses of the superior varieties to changes in their respective expected yields are also positive. The responses of MV wheat and rice area to changes in their expected yields are more than twice their response to own expected price.

The results also suggest that the dry and irrigated varieties in the *rabi* season compete with each other as incentives change and the constraints are relaxed, while some of the *kharif* irrigated and dry varieties do not. Further, the *kharif* varieties compete with the *rabi* varieties for irrigated area. In general, an expansion in irrigated area favors the *rabi* crops at the expense of the *kharif* crops. As noted earlier, this finding is consistent with the possibility that further increases in irrigated crops in the *rabi* season require land to be left fallow in the *kharif* season.

The implications of the intertechnique effects due to changes in incentives and the availability of quasi-fixed inputs are assessed by obtaining elasticities of the total area allocated to each crop (over all techniques).

The own-price elasticities of total area planted to wheat and gram in the *rabi* season are all negative. For instance, a value of −0.033 is obtained for wheat. On the other hand, the corresponding values for the *kharif* crops are all positive. Given this finding and the fact that the own-price area elasticities for the superior varieties of each crop are all positive, it appears that the competition between varieties of a particular crop is greater in the *rabi* season than in *kharif* season. In contrast to the own-price elasticities, the area elasticities by crop with respect to the expected yield of the superior varieties are all positive.

Although the area elasticities by variety suggest considerable substitutions within the varieties of both wheat and rice as the availability of the quasi-fixed inputs increased, the net effects for total wheat and rice area due to changes in any of these variables are all positive. Further, the magnitude of these elasticities are large relative to the elasticities of wheat and rice area with respect to the incentive variables.

In addition, the area elasticities indicate that area allocated to maize increases as net cropped and irrigated area increase, yet decreases as the availability of roads and fertilizers increases. Area allocated to cotton increases as new land is brought into production but decreases as dry cropped land is irrigated and as the availability of fertilizer increases.

## Determination of Yield

The specific variables included in the yield equations and the results are described in Tables 15 and 16, respectively. Note that no price variables are included in any of the final yield equations, as their coefficients were all insignificant. This finding is discussed in detail below.

With the exception of gram yield, the equations fit the data well. The significant technology variables indicate the importance of the composition of techniques, chosen in the earlier planting decisions, in the determination of overall yield by crop. That is, these variables indicate the importance of the amount of area allocated to MV wheat and rice and to irrigated gram, maize, and cotton in overall yield enhancement. The technology effect is particularly important in wheat, rice, and maize. To assess the full impact of a change in the choice of technique on yield, the coefficients on the interaction variables of technology with fertilizer and rain should also be considered. However, with the exception of the technology-fertilizer variable in the cotton equation and the technology-rain variable in the wheat equation, the coefficients on these variables are not significantly different from zero and therefore are ignored.

The availability of fertilizer per net cropped area has a positive effect on the yields of all crops. However, the effect is weak and, with the exception of cotton, is not significant. The least significant intratechnique effects due to an increase in

**Table 15—Definition of variables: yield equations**

| Variable | Definition | Equation |
|---|---|---|
| Technology | | |
| IRRIGATED COTTON | Proportion of cotton area irrigated | Cotton |
| IRRIGATED MAIZE | Proportion of maize area irrigated | Maize |
| MV RICE | Proportion of rice area in modern varieties | Rice |
| MV WHEAT | Proportion of wheat area in modern varieties | Wheat |
| IRRIGATED GRAM | Proportion of gram area irrigated | Gram |
| AMERICAN COTTON | Proportion of cotton area in American variety | Cotton |
| Constraint | | |
| FERTILIZER | Fertilizer available per net cropped area (nutrient kilograms of $N, P_2O_5, K_2O$/hectare) | All |
| Environment | | |
| COTRAIN | District rainfall (cm) June-September | Cotton |
| KHARAIN | District rainfall (cm) July-September | Maize, rice |
| RABRAIN | District rainfall (cm) October-April | Wheat, gram |
| DISTRICT | A dummy variable is introduced for each district[a] | All |

Note: All yields are measured in metric tons per hectare.

[a] The districts are listed in Table 16.

## Table 16—Estimates of yield equations

| Explanatory Variable | Dependent Variable: Yield | | | | |
|---|---|---|---|---|---|
| | Wheat | Gram | Rice | Maize | Cotton |
| Technology | | | | | |
| MV WHEAT | 1.19928<br>(12.12) | ... | ... | ... | ... |
| IRRIGATED GRAM | ... | 0.2215<br>(0.64) | ... | ... | ... |
| MV RICE | ... | ... | 1.32789<br>(7.18) | ... | ... |
| IRRIGATED MAIZE | ... | ... | ... | 2.07472<br>(4.66) | ... |
| IRRIGATED COTTON | ... | ... | ... | ... | 0.41771<br>(3.15) |
| AMERICAN COTTON | ... | ... | ... | ... | 0.11413<br>(4.49) |
| Constraints | | | | | |
| FERTILIZER | 0.00316<br>(1.30) | 0.00141<br>(1.66) | 0.00189<br>(1.00) | 0.00201<br>(1.46) | 0.00116<br>(2.2) |
| FERTILIZER × TECHNOLOGY | -0.00301<br>(-1.27) | -0.00314<br>(-1.69) | 0.00115<br>(0.59) | -0.00121<br>(-0.74) | -0.00135<br>(-2.45) |
| Environment | | | | | |
| RAIN[a] | -0.00955<br>(-2.12) | -0.00437<br>(-0.64) | 0.00212<br>(0.94) | -0.00118<br>(-0.36) | 0.002306<br>(1.58) |
| RAIN[a] × TECHNOLOGY | 0.00342<br>(0.53) | 0.00622<br>(0.35) | 0.00183<br>(0.59) | -0.01200<br>(-2.82) | -0.002679<br>(-1.69) |
| GURDASPUR | -0.04956<br>(-0.52) | 0.15099<br>(1.50) | -0.26179<br>(-2.14) | 0.28494<br>(1.86) | -0.01734<br>(-0.55) |
| AMRITSAR | 0.02278<br>(0.28) | 0.24668<br>(1.61) | -0.04082<br>(-0.36) | -0.4578<br>(-3.03) | -0.05036<br>(-3.62) |
| KAPURTHALA | -0.14989<br>(-1.87) | -0.06487<br>(-0.67) | 0.08303<br>(0.73) | -0.44721<br>(-3.07) | -0.01692<br>(-1.07) |
| JULLUNDUR | -0.01944<br>(-0.24) | 0.18406<br>(1.96) | 0.09981<br>(0.86) | -0.07571<br>(-0.58) | -0.01692<br>(-1.12) |
| FEROZEPORE | -0.05916<br>(-0.73) | 0.03467<br>(0.37) | 0.15042<br>(1.26) | -0.77452<br>(-5.32) | 0.04403<br>(2.70) |
| LUDHIANA | 0.56211<br>(6.83) | 0.15204<br>(1.39) | 0.10365<br>(0.89) | 0.13624<br>(0.93) | 0.02481<br>(1.80) |
| BHATINDA | 0.0199<br>(0.24) | -0.0135<br>(-0.15) | 0.2426<br>(2.03) | -0.80803<br>(-4.77) | 0.04682<br>(3.25) |
| SANGRUR | -0.02861<br>(-0.35) | 0.06731<br>(0.69) | 0.02659<br>(0.23) | -0.45212<br>(-2.73) | 0.0337<br>(2.09) |
| INTERCEPT | 1.43853<br>(16.44) | 0.71832<br>(5.80) | 0.93329<br>(6.13) | 0.41233<br>(1.32) | -0.14679<br>(-1.18) |
| $R^2$ | 0.8314 | 0.172 | 0.8334 | 0.5388 | 0.7164 |

Notes: The numbers in parentheses are t-statistics. See Table 15 for definitions of variables.

[a] The relevant rain variables include RABRAIN for wheat and gram yields, KHARAIN for rice and maize yields and COTRAIN for cotton yields.

fertilizer are found in the wheat and rice yield equations. These responses to fertilizer are obtained conditional on the composition of techniques and thus reflect the intratechnique effect or the change in yield due to movements along the relevant production functions. It is important to emphasize that these results are not necessarily inconsistent with the findings that yields are responsive to fertilizers in field experiments. What happens in practice is that results from such experiments are used to develop fertilizer recommendations, which are disseminated to farmers in one form or another. Thus, individual farmers do not have to experiment over the entire domain of potential fertilizer doses, and observed intratechnique variations over the implemented range of doses are relatively small. This is particularly true with aggregated data, since any interfarm differences are not detected.

The difficulty in capturing an intracrop input response, or in this case, an intratechnique input response, has been discussed in the literature. For example, Mundlak (1959) found no correlation between preharvest labor inputs and yields of sugar beets in Israel. In this particular case, the explanation of the finding was similar to that above; all farmers carried out the same recommended operations. Observed variations in labor inputs reflected other factors, including variations in the timing of the operation, and thus did not reflect a movement on a given production function.

If levels of other inputs applied to a specific variety also follow closely the recommendations given to farmers, one would expect to observe, as in this study, that once a farmer has chosen a particular technique of production, prices do not significantly affect yields. A similar finding was also reported in Mundlak and McCorkle 1956. More recently, although in a somewhat different context, a similar view has been developed by Just et al. (1990).

It is only against this background that one can fully assess the importance of the intertechnique response. Recall that an increase in the availability of fertilizer has a strong positive effect on the share of irrigated land allocated to modern wheat and rice. Thus the yield results suggest that the main effect of fertilizer on the overall yields of wheat and rice is through changes in crop composition. This result can be illustrated in terms of Figure 32 by letting $\bar{x}$ represent the quantity of fertilizer available per unit of land. As x increases beyond $\bar{x}$, farmers do not change the rate of application on each variety, but the composition of varieties changes. Bapna (1981, 35) made a similar observation, also in the Indian context; ". . .the increase in the use of fertilizer was mainly because of extension of area under fertilizer rather than due to higher per hectare dosage. . . . The same is true of irrigation."

As noted above, the only significant interaction term involving fertilizer is the technology-fertilizer variable in the cotton equation. This finding also reflects an intertechnique response. Recall that an increase in the availability of fertilizer significantly reduces the area allocated to irrigated cotton. Given the higher yields of irrigated cotton, overall cotton yield should decrease as more fertilizer becomes available.

For the most part, the rainfall variables and the rainfall-technology interaction variables are insignificant. An exception to this finding is the negative coefficient on rainfall in the wheat yield equation. A possible explanation of this result relates to the effect of rainfall on area allocations. Larger rainfall during the growing season increases the area of dry traditional wheat, and this in turn reduces the average yield. The negative coefficient on the technology-rain interaction term in the maize yield equation may be explained using similar reasoning. The negative coefficient indicates that maize yields decrease as more rain becomes available and that the extent of the decrease is positively related to the amount of area that is planted to irrigated maize. Given that areas with more rainfall during the *kharif* season are likely to grow more (lower-yielding) dry maize than the other drier districts, this finding is not surprising.

The district effects are particularly important in the determination of maize and cotton yields. For the most part, they appear to capture the influence of soil type and climate in crop rotations. The results confirm the fact that the light and sandy soils of the arid southwest (Bhatinda, Ferozepore, and Sangrur) are unsuitable for the production of maize. The lack of significant district effects in the gram yield equation reflects the fact that gram can be grown on a whole range of soil types. The lower yields of rice and wheat in Gurdaspur reflect the fact that Gurdaspur has the highest rainfall of all districts and consequently grows more unirrigated crops than any of the other districts. The particularly high yields of wheat and maize in Ludhiana may reflect, in part, the impact of the special attention Ludhiana has received as a participant in the Intensive Agricultural District Program since 1961/62 and also its close proximity to the Punjab Agricultural University, where much of the work on the new varieties has taken place.

The total effect of the state variables on the overall yields for each crop is observed by deriving elasticities of yield with respect to the state variables. These elasticities incorporate the direct effect of the state variables included in the yield equations and the indirect effects of these variables on the composition of techniques—a major determinant of yield levels. The results appear in Table 17.

Even after the indirect effects of the state variables are taken into account, their overall effects on yields are small when compared with their effects on area allocation. With the exception of cotton, all own-price elasticities, though small, are positive. For the most part, a much stronger response in overall yield occurs as the constraints are relaxed. The strongest effects are observed for rice yields with respect to the availability of fertilizer and roads, and for wheat and maize yields with respect to the conversion of dry land to (private or government) irrigated area. When compared with the other crop yields, the response of gram and cotton yields to changes in the constraints is small.

### Summary: Yield Results

To summarize the yield results, three observations are made. First, yields increase as the share of the MVs and irrigated crops increase. This is hardly a surprising result. Yet it reemphasizes the importance of the area allocation equations. In particular, yields are affected indirectly by the level of the constraints.

Second, the empirical results are consistent with the common knowledge that fertilizers are important in increasing yields. However, the direct or intratechnique effect of fertilizers on yields, holding variety composition constant, is not very pronounced. The main effect is through the change in variety composition (intertechnique). As indicated in Chapter 3, resource constraints may have limited the availability of fertilizer and thus constrained yields directly as well as indirectly through the choice-of-technique decision.

## Table 17— Average overall yield elasticities

| Variable | Wheat | Gram | Rice | Maize | Cotton |
|---|---|---|---|---|---|
| Expected prices | | | | | |
| WHEAT | 0.073 | -0.009 | . . . | . . . | . . . |
| GRAM | 0.000 | 0.009 | . . . | . . . | . . . |
| RICE | . . . | . . . | 0.046 | -0.004 | -0.011 |
| MAIZE | . . . | . . . | -0.009 | 0.010 | 0.009 |
| COTTON | . . . | . . . | 0.024 | 0.007 | -0.009 |
| Constraints | | | | | |
| IRRIGATION[a] | | | | | |
| PRIVATE | 0.176 | 0.008 | -0.077 | 0.272 | 0.050 |
| GOVERNMENT | 0.049 | 0.056 | 0.023 | 0.075 | 0.059 |
| AREA[b] | | | | | |
| PRIVATE IRRIGATION | 0.057 | -0.005 | -0.085 | 0.047 | -0.016 |
| GOVERNMENT IRRIGATION | -0.044 | 0.018 | 0.018 | -0.032 | 0.042 |
| DRY | -0.065 | -0.039 | 0.000 | -0.107 | -0.014 |
| FERTILIZER[c] | 0.051 | 0.026 | 0.092 | 0.092 | -0.013 |
| ROADS[d] | 0.015 | 0.001 | 0.252 | -0.124 | -0.044 |

Notes: Elasticities are calculated by simulating the model (with fixed quasi-fixed inputs) with the appropriate changes (for example, rice price = rice price × 1.01) and comparing results with the base-run predictions. Elasticities reflect changes in the mean area for Punjab over the sample period from the base run. Note that these elasticities incorporate the indirect effect of a change in choice of technology on yield.

[a] The expansion in irrigated area occurs through a conversion of dry land to irrigated land.

[b] The expansion in net cropped AREA is analyzed under three different assumptions: the expansion occurs through an increase in PRIVATEly irrigated lands, the expansion occurs through an increase in land irrigated by the GOVERNMENT, and the expansion occurs through an increase in net DRY area.

[c] Availability of fertilizer per net cropped area.

[d] Kilometers of road available per hectare.

Last, the importance of the local environment on productivity is well illustrated by the significant district effects.

## Output Elasticities

The area and yield results are now combined to obtain the determinants of output in the short run. The importance of the incentives and the availability of quasi-fixed inputs in the determination of output is assessed by analyzing the short-run or conditional output elasticities for the five major crops. (For a discussion of how these elasticities are calculated, see the earlier section, Area Elasticities by Technique.) Elasticities of total aggregate production with respect to the various variables are also calculated.[29] The average elasticities for the period as a whole are summarized in Table 18.

To a large extent, the results reiterate the previous results. With the exception of gram, all own-price elasticities are positive and generally small. These findings are in line with results reported in other studies (for example, Askari and Cum-

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[29] The change in total production is calculated using a Normalized Quadratic Quantity Index (see Diewert 1976).

**Table 18 — Average short-run crop output elasticities**

| Variable | Wheat | Gram | Rice | Maize | Cotton | Total Production[a] |
|---|---|---|---|---|---|---|
| Expected prices | | | | | | |
| WHEAT | 0.107 | -0.156 | . . . | . . . | . . . | 0.066 |
| GRAM | -0.010 | -0.071 | . . . | . . . | . . . | -0.014 |
| RICE | . . . | . . . | 0.114 | -0.036 | 0.043 | 0.035 |
| MAIZE | . . . | . . . | -0.016 | 0.144 | -0.020 | 0.005 |
| COTTON | . . . | . . . | 0.070 | -0.049 | 0.043 | 0.005 |
| All prices | 0.096 | -0.227 | 0.168 | 0.059 | 0.067 | 0.075 |
| Expected yields | | | | | | |
| MV WHEAT | 0.251 | -0.079 | . . . | . . . | . . . | 0.170 |
| IRRIGATED GRAM | -0.014 | 0.106 | . . . | . . . | . . . | -0.002 |
| MV RICE | . . . | . . . | 0.109 | -0.043 | 0.051 | 0.012 |
| IRRIGATED MAIZE | . . . | . . . | -0.020 | 0.144 | -0.017 | 0.008 |
| IRRIGATED COTTON | . . . | . . . | 0.062 | -0.048 | 0.041 | 0.006 |
| Constraints | | | | | | |
| IRRIGATION[b] | | | | | | |
| PRIVATE | 0.483 | -1.316 | 0.194 | 0.489 | 0.017 | 0.331 |
| GOVERNMENT | 0.398 | -1.168 | 0.025 | 0.592 | -0.247 | 0.246 |
| AREA[c] | | | | | | |
| PRIVATE IRRIGATION | 0.473 | -0.070 | 0.349 | 0.483 | 0.389 | 0.419 |
| GOVERNMENT IRRIGATION | 0.426 | 0.391 | 0.193 | 0.449 | 0.249 | 0.383 |
| DRY | 0.041 | 0.858 | 0.091 | -0.027 | 0.232 | 0.107 |
| FERTILIZER[d] | 0.060 | -0.180 | 0.243 | 0.023 | -0.080 | 0.062 |
| ROADS[e] | 0.084 | 0.257 | 0.658 | -0.298 | 0.254 | 0.152 |

Notes: Elasticities are calculated by simulating the model (with fixed quasi-fixed inputs) with the appropriate changes (for example, rice price = rice price × 1.01) and comparing results with the base-run predictions. Elasticities reflect average changes in crop output for Punjab over the sample period from the base run.

[a] Change in total production is calculated using a Normalized Quadratic Quantity Index (see Diewert 1976).

[b] The expansion in irrigated area occurs through a conversion of dry land to irrigated land.

[c] The expansion in net cropped AREA is analyzed under three different assumptions: the expansion occurs through an increase in PRIVATEly irrigated lands, the expansion occurs through an increase in land irrigated by the GOVERNMENT, and the expansion occurs through an increase in net DRY area.

[d] Availability of fertilizer per net cropped area.

[e] Kilometers of road available per hectare.

mings 1976). The own elasticities of output with respect to expected yields for each of the superior varieties are positive and are highest for wheat.

The output elasticities with respect to the constraints indicate output response to a change in the particular constraint being analyzed, holding all other constraints at their sample values. The output elasticities of wheat and rice with respect to all the constraints are sizable and positive. They appear particularly sizable when compared with the price elasticities. This, once more, indicates that the constraints were indeed binding. Note that among the quasi-fixed inputs, changes in the availability of irrigation (private and government) lead to the largest increases in total crop production.

As indicated earlier, the response of the system to a change in a state variable will depend on the productivity of the implemented technology; the more productive the implemented technology, the greater the response (in absolute value). Figures 33-36 show selected results describing the time pattern of the output elasticities. The short-run output elasticity of wheat with respect to its own price changes from nearly zero in the pre-modern variety period to roughly 0.22 at the end of the period (Figure 33). The elasticity of rice output with respect to its own

Figure 33—Short-run output elasticities with respect to own price, 1962-79

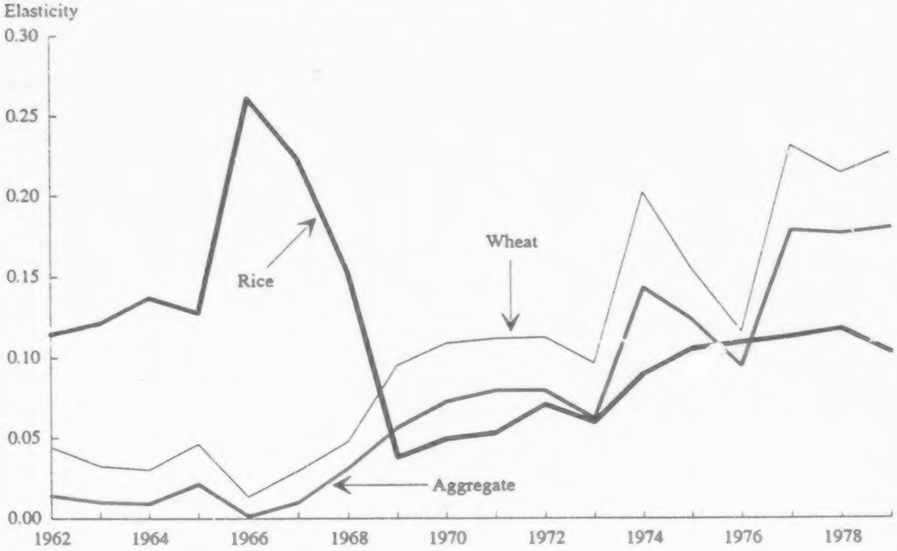


Figure 34—Short-run output elasticities with respect to private irrigation, 1962-79

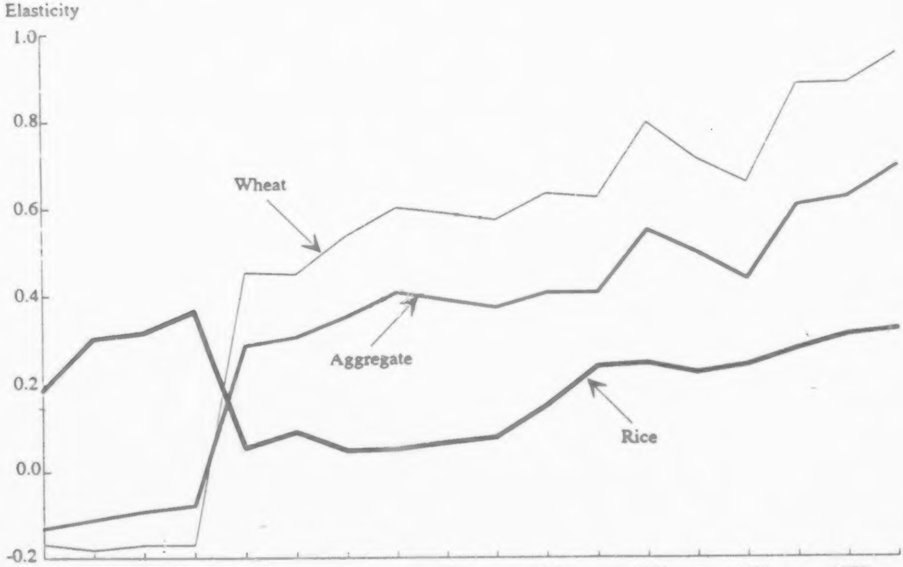


Figure 35— Short-run output elasticities with respect to fertilizer, 1962-79

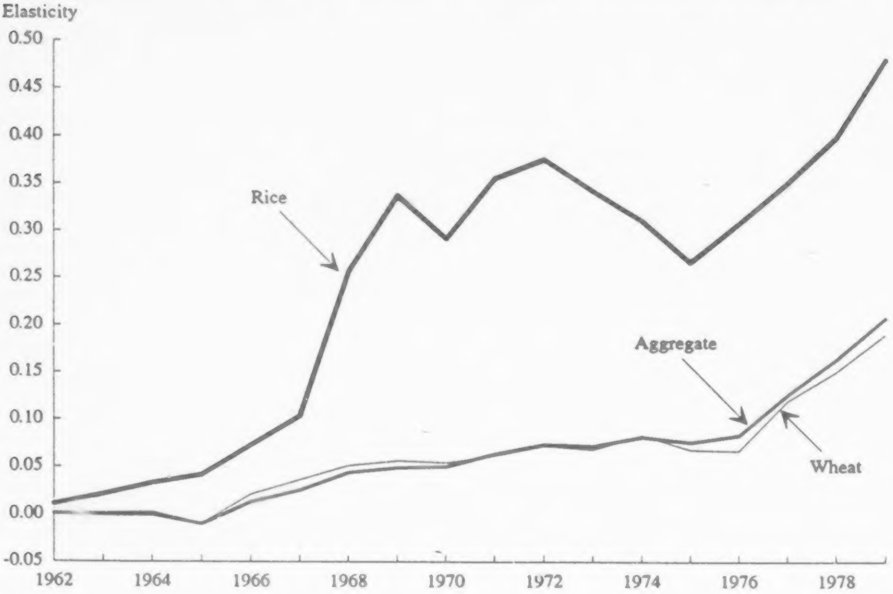
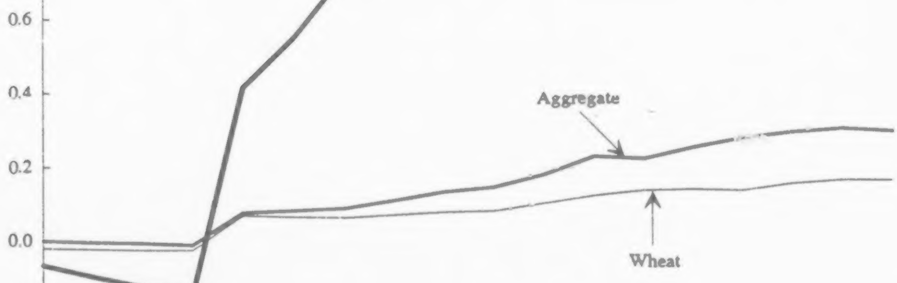


Figure 36— Short-run output elasticities with respect to roads, 1962-79



price was initially stable around 0.13, but then increased to 0.25 in 1966. Beginning in 1966, with the appearance of MV wheat, the own-price elasticity of rice dropped sharply, reaching an all-time low of 0.04 in 1969. From 1969 onward, the own-price elasticity increased with the growing importance of the MV of rice. By the end of the study period, the elasticity appeared to be stabilizing around 0.11. When all prices increased, the short-run aggregate output or supply elasticity changed from nearly zero in the early 1960s to 0.18 in 1979. This finding indicates that when new techniques appear, aggregate output increases as prices increase.

Turning to the output elasticities with respect to the constraints, Figure 34 shows the elasticity of wheat output with respect to an increase in private irrigated area, holding total net cropped area constant. Before the onset of the green revolution, the output elasticity of wheat was negative and very small. Once MVs of wheat were introduced, the elasticity jumped from −0.17 in 1965 to 0.45 in 1966. It then continued to climb as more and more land was sown to the MVs, reaching an elasticity close to 1.0 by the end of the study period. The time pattern of the rice output elasticity with respect to this same variable is very different, reflecting the different adoption path of MV rice. In the early 1960s, the elasticity was between 0.19 and 0.37. By 1966, it had dropped to 0.05, but thereafter started to increase gradually, reaching 0.32 in 1979. Reflecting the increases in overall productivity over the study period, the elasticity of aggregate output with respect to private irrigation increased from a small negative value in the early 1960s to 0.70 at the end of the study period.

While the elasticities of output with respect to irrigation are sizable, those with respect to fertilizers are considerably smaller. Prior to the onset of the green revolution, the elasticities of output for both wheat and rice with respect to fertilizer were negligible (Figure 35). This is consistent with the weak intratechnique response discussed above. As the MVs were adopted, these elasticities increased, reaching 0.19 and 0.48 for wheat and rice, respectively, by 1979. A comparison of these elasticities with the same output elasticities with respect to private irrigation indicates that the scope for increasing output through the application of more fertilizer, holding irrigation fixed, is much smaller than that generated by increasing irrigation with fertilizer supply held constant.

Finally, the elasticities with respect to roads are plotted in Figure 36. They increased from small negative values in the early 1960s to 0.17, 0.96, and 0.30 for wheat, rice, and aggregate output, respectively, in 1979. These results suggest that roads were more important in the transition to MV rice than wheat.

# 6

# THE LONG-RUN RESPONSE

## The Framework

The analysis has brought forth the importance of irrigation and fertilizer availability in the transition to the MVs of wheat and rice and to increased output of other crops. The large elasticities with respect to these quasi-fixed inputs indicate that the pace of the transition was largely determined by the pace of their expansion. The next step is to examine the determinants of the levels of these inputs. In so doing it is important to keep in mind that the increased availability of fertilizer and canal irrigation reflects decisions made by the government and thus is exogenous to the individual farmer. On the other hand, expansions in area irrigated by tubewells and other wells and net cropped area largely reflect decisions made by farmers themselves.

Although the decisions to expand the quasi-fixed inputs are made by both the private and public sectors, some of the factors affecting these decisions are similar. The similarities stem from the fact that expansion decisions require scarce resources; therefore, the diversion of resources to agriculture requires that their value productivity in agriculture is greater than that in other uses. Despite the similarities, however, farmers decisions differ from those of the government in that farmers consider only private returns. If the government's sole objective were to maximize per capita private consumption over time and there were no externalities, it would behave in the same way as the private sector. Given that the provision of public goods usually involves externalities, the behavior of the two sectors will differ. In reality, however, the behavior of the two sectors differs for other reasons as well. Governments usually have other motives and objectives, including the desire to stay in power. This study will only try to determine empirically the importance of economic incentives in the government's investment decisions.

The most drastic change in irrigation took place in area irrigated by private sources, which more than doubled between 1966 and 1979 (see Figure 20). Over the same period, land irrigated by government sources increased only by 17 percent. Thus, while in 1966 the areas irrigated by private and public sources were 953,000 and 1.26 million hectares, respectively, the corresponding figures in 1979 were 1.91 million and 1.48 million hectares.[30] Although both the private and public sectors seem to have responded to the favorable economic conditions of the period, the particularly large increase in private irrigation is an important indication of the intensity with which farmers will respond when the opportunities arise.

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[30] Note that the data on the quasi-fixed inputs described here include only the quasi-fixed inputs in the 10 districts incorporated in this study (see Chapter 5).

The framework for the analysis of changes in the quasi-fixed inputs over time is provided by equation (26); an optimal level of capital stock is achieved when its net marginal-value productivity is equal to its user cost. The net marginal-value productivity of capital is obtained by differentiating the restricted profit function with respect to capital. It measures the change in value output, net of the cost of variable inputs, associated with a change in capital stock by one unit.

The solution to equation (26), which gives the optimal time path of capital, can be written as $K^*(z)$, where $z = [s,r,T,q,qc(\dot{K}),\dot{q}]$ and s is the vector of state variables (z) entering the restricted profit function (equation [11]) defined in equation (8), r is the discount rate, T is the available technology, q is the price of K, $qc(\dot{K})$ is the cost of adjusting K, and $\dot{q}$ is the first time derivative of q. The demand for investment is the difference between the optimal level of capital and that currently available:

$$I^d[z(t)] = K^*[z(t)] - K(t). \tag{31}$$

The generalization of this discussion to more than one quasi-fixed input is straightforward.

Equation (31) represents the decisions made at the farm level, where all prices are exogenous. Thus the variables should have a farm index, say i. The aggregate demand for investment at the sector level is obtained by summing equation (31) over all farms. Just as in the case of investment at the farm level, the aggregate demand for investment is a function of the state variables (z) indicated in equation (31). At the sectoral level, however, these variables are no longer necessarily exogenous to the investment decision. This is particularly true for prices, and more specifically, for the price of the capital good, q, which is determined by the supply and demand for that good. If the supply of capital is perfectly inelastic, an increase in demand will be absorbed entirely by an increase in the shadow price of capital. On the other hand, if the supply is perfectly elastic, an increase in the demand for capital is fully reflected in increases in investment, and the price of capital does not change. In the intermediate case, when the supply curve of capital is upward-sloping, increases in investment demand result in an increase in both the price of capital and the level of the capital stock.

For the problem at hand, where quasi-fixed inputs are fixed in the short run, an increase in the demand for agricultural products only leads to an increase in the shadow prices of the constraints. As the shadow prices of the constraints increase, however, resources should move into the agricultural sector. Because resources are limited and have to be bid away from other activities where their return is not as high, the process can take considerable time. This implies that the level of investment in agriculture, or more generally in any sector, will depend on the overall availability of resources and on the profitability of the particular sector in question relative to the rest of the economy. The profitability of the agricultural sector depends on the cost of the variable inputs and product prices, which in turn reflect the overall demand for food. Because prices are also influenced by government policies, a clearer view of the role of the demand for food is assessed by including additional factors that also reflect changes in demand.

Although this conceptual framework forms the basis of the analysis, compromises had to be made in its implementation to deal with the available data. Nevertheless, the qualitative nature of the results is instructive.

In general terms, it is hypothesized that the flow of resources to the agricultural sector depends on the profitability of this sector relative to the nonagricultural sector, the overall level of resources in the economy as a whole, and additional factors influencing or reflecting demand conditions.

Similar hypotheses have been tested empirically in other studies by explaining the share of total investment allocated to agriculture as a function of the expected intersectoral differential rates of return, the composition of the capital stock, and related variables (Mundlak and Strauss 1979; Cavallo and Mundlak 1982; Coeymans and Mundlak 1987; Barkley 1988; and Mundlak, Cavallo, and Domenech 1989). Once the share of total investment allocated to agriculture and total investment itself is determined, agricultural investment is obtained. In turn, this investment can be allocated to the various major agricultural capital items according to their profitability. This approach to explaining investment requires data on investment, capital stock, and sectoral rates of return, none of which are available at the district level. Such data could be assembled by states for India, but such an effort is beyond the scope of this study.

Alternatively, the approach taken here is to explain the important components of investment: net cropped area (AREA), net irrigated area by source (PRIVATE and GOVERNMENT), and the availability of fertilizer per net cropped area (FERTILIZER) using the available data. The variables entering these equations are discussed below.

The measure of relative sectoral rates of return is a ratio of the average revenue per hectare from the various cropping activities relative to per capita income in nonagriculture. The nonagricultural income is calculated for the state as a whole, whereas the agricultural measure varies by district. The changes in the profitability of agriculture brought about by technical change are captured by this variable. This variable (SECPROF) is expressed as an index, with the average value of the same variable for 1960-66 serving as the base.

A direct measure of resource availability is not available, as there are no annual data on total capital by district. As an alternative, per capita output is utilized. This measure, introduced by Mundlak and Hellinghausen (1982), can be shown to represent the availability of comprehensive (physical and human) capital under the assumption that the aggregate production function, properly specified, is constant returns to scale in labor and all forms of capital, physical and human. Hence, average labor productivity can be written as $y = F(k_p,k_h)$, where y is the aggregate output per unit of labor and $k_p$ and $k_h$ are vectors of the various physical and human capital components divided by the labor force. This expression indicates that y can be interpreted as a natural aggregate of human and physical capital. The per capita state output measured in constant prices (INCOME) is included as a proxy for y.

As equation (31) indicates, the level of investment also depends on the existing capital stock. The available stock is represented by the lagged dependent variable. In the case of the AREA equation, rather than including lagged net cropped area, its individual components (lagged PRIVATE and GOVERNMENT IRRIGATION area and DRY area) are included separately. Such a decomposition allows the various components of lagged net cropped area to have different effects on the investment decisions. A similar argument explains the inclusion of the same components in the equation explaining private irrigation. Population pressure, measured by population density, is included to represent the expected increase in demand for agricultural output. Finally, lagged total fertilizer per cropped hectare is included as an indication of fertilizer availability.

As indicated earlier, the allocation of resources by the government may in fact be influenced by factors similar to those influencing the private sector. Thus, even though the government may have objectives different from those of individuals, the very fact that resources are limited implies that government should give more weight to areas or projects that are most productive. Districts vary by their productivity and therefore by their rate of return. To examine whether the agricultural productivity of one district relative to the other districts has an influence on the government's resource allocation decisions, a measure of the value of production per net cropped area of each district relative to the average productivity per hectare for the state (DISTPROF) is constructed and included in the fertilizer and government irrigation equations.

In addition to the profitability variable, the allocation of fertilizer to the various districts of Punjab (per net cropped hectare) is determined by the availability of roads and the availability of irrigation.

## Results

Definitions of variables included in the equations to explain the four quasi-fixed inputs are summarized in Table 19. The equations were estimated simultaneously with the rest of the system. The results are presented in Table 20.

### Table 19 — Definition of variables: quasi-fixed input equations

| Variable | Definition |
|---|---|
| Dependent variables | |
| AREA | Net cropped area (1,000 hectares) |
| PRIVATE IRRIGATION | Net irrigated area (private) (1,000 hectares) |
| GOVERNMENT IRRIGATION | Net irrigated area (government) (1,000 hectares) |
| FERTILIZER | Total fertilizer/net cropped area (kilograms of nutrients/hectare) |
| Independent variables | |
| DRY AREA | Net cropped area not irrigated (1,000 hectares) |
| SECPROF | Index: value of agricultural production/nonagricultural net domestic product (NDP) (t−1)[a] |
| POPDEN | Population/area (people/million hectares) |
| INCOME | Real state NDP (Rs 10 million) per capita |
| E FERTILIZER | Fertilizer (t−1) |
| DISTPROF | Value of production/hectare (t−1) deflated by average value of production/hectare (t−1) for all districts |
| ROADS | Roads (kilometers)/1,000 hectares |
| DISTRICT | A dummy variable is introduced for each district[b] |

[a] This variable is expressed as an index with the average value of the the same variable serving as a base.

[b] The districts are listed in Table 20.

## Table 20 — Estimates from capital equations

| Explanatory Variable | Dependent Variable | | | |
|---|---|---|---|---|
| | AREA | PRIVATE IRRIGATION | GOVERNMENT IRRIGATION | FERTILIZER |
| Incentives | | | | |
| SECPROF | -2.10395 | 33.7034 | . . . | . . . |
| | (-0.57) | (7.06) | | |
| DISTPROF | . . . | . . . | -3.058 | 13.756 |
| | | | (-0.39) | (1.73) |
| POPDEN | 0.01951 | -0.019 | . . . | . . . |
| | (3.13) | (-1.99) | | |
| Availability of resources | | | | |
| INCOME | -0.59157 | 2.607 | 2.136 | . . . |
| | (-0.24) | (0.63) | (0.97) | |
| E FERTILIZER | . . . | 0.139 | . . . | . . . |
| | | (1.69) | | |
| ROADS | . . . | . . . | . . . | 25.698 |
| | | | | (12.61) |
| Other | | | | |
| DRY AREA (t-1) | 0.06734 | -0.096 | 0.026 | . . . |
| | (1.03) | (-1.14) | (0.42) | |
| PRIVATE IRRIGATION (t-1) | 0.14044 | 0.806 | 0.019 | -0.016 |
| | (2.05) | (8.88) | (0.29) | (-0.38) |
| GOVERNMENT IRRIGATION (t-1) | 0.08352 | 0.132 | 0.664 | -0.066 |
| | (0.86) | (1.31) | (8.75) | (-1.55) |
| Fixed effects | | | | |
| GURDASPUR | -123.64 | -15.42939 | 8.82658 | -27.54788 |
| | (-7.60) | (-0.93) | (0.91) | (-1.09) |
| AMRITSAR | -5.22488 | -28.9003 | 60.19312 | 28.47981 |
| | (-0.22) | (-1.93) | (5.97) | (0.73) |
| KAPURTHALA | -222.7 | -26.97111 | -7.98002 | 55.45109 |
| | (-12.39) | (-1.24) | (-0.5) | (0.58) |
| JULLUNDUR | -122.7 | -25.32409 | -6.59003 | 2.15611 |
| | (-8.66) | (-1.32) | (-0.82) | (0.09) |
| FEROZEPORE | 439.19 | -63.18901 | 138.79 | 47.62404 |
| | (10.14) | (-1.38) | (4.16) | (1.65) |
| LUDHIANA | -83.20416 | 21.35437 | -2.80727 | 49.99803 |
| | (-7.6) | (1.53) | (-0.39) | (1.57) |
| BHATINDA | 267.65 | -63.32079 | 118.57 | 34.97265 |
| | (8.94) | (-1.98) | (4.95) | (1.26) |
| SANGRUR | 70.66944 | -20.18259 | 31.84535 | 8.78769 |
| | (6.00) | (-1.91) | (4.06) | (0.33) |
| INTERCEPT | 292.7 | 44.39443 | -1.12094 | -38.2759 |
| | (12.42) | (1.25) | (-0.05) | (-1.5) |
| $R^2$ | 0.9977 | 0.9492 | 0.992 | 0.9228 |

Notes: Numbers in parentheses are t-statistics. See Table 19 for definitions of variables.

Recall that the two key determinants of investment are largely represented by state-level variables.[31] Thus they measure only variations over time that are uniform to all districts. Further, both these variables exhibit a trend that reflects the increase in productivity over the relatively short period analyzed. As a consequence, multicollinearity, as indicated by high $R^2$'s and low t-values for many of the coefficients, appears to be a problem. To help alleviate the problem, some variables included in the initial specification of the equations have been dropped. Thus the results should be interpreted as suggestive until substantiated with additional evidence. With this caveat, the results are now reviewed.

The overall fit ($R^2$) of each equation is high. The quasi-fixed input most responsive to economic stimuli is area irrigated by private sources. Recall that, among the quasi-fixed inputs analyzed, private irrigated area increased the most over the period under consideration. What is more important is that these changes occurred as a result of decisions made by farmers themselves. Private irrigated area shows a very distinct response to the measure of differential intersectoral productivity (SECPROF). It also responded positively to the proxy for comprehensive capital (INCOME) but the coefficient is not significant. The population density has a negative sign, opposite to that obtained in the net cropped area (AREA) equation. In terms of Ricardian analysis, this result suggests that population pressure favored the extensive margin at the expense of the intensive margin. For this explanation to hold, the expansion of the extensive margin requires resources. Because the verdict on this hypothesis is not crucial for the present analysis, it is left as a working hypothesis for future investigation.

Note that the steady state response of private irrigated area to changes in the state variables is larger than that indicated by the reported coefficients, which have to be augmented by taking into account the coefficients of the lagged dependent variables.

In 1965/66, 76 percent of the geographical area in Punjab was being cultivated. Thus the scope for expansion in net cropped area has been rather limited. Figure 37 indicates that it only changed approximately 10 percent over the sample period. The results suggest that changes in net cropped area are best explained by increasing population pressure as represented by population density and by area irrigated by private sources. Thus, expansions in net cropped area are indirectly responsive to changes in incentives and the availability of comprehensive capital.

As indicated, area irrigated by government sources expanded only by 17 percent over the period 1965-79 (Figure 20). The changes in area irrigated by government sources may reflect the supply conditions of unused water sources suitable for canal irrigation. This may partially explain the results, which indicate that area irrigated by government sources is not influenced by the economic variables under consideration.

The amount of fertilizer allocated to the various districts was positively and strongly affected by the availability of roads and positively affected by the differential productivity of each district (DISTPROF). Thus it appears that the fertilizer

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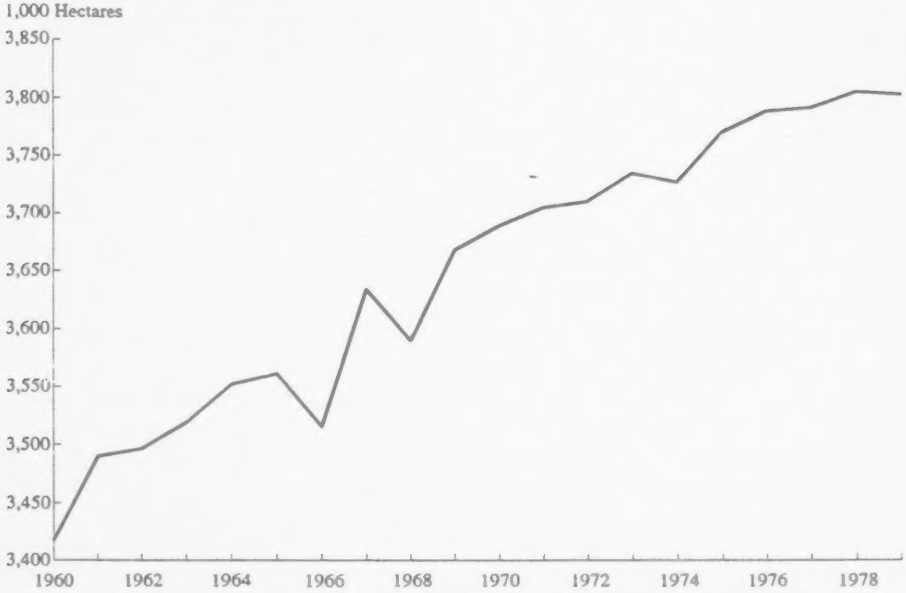
[31] These variables are the measure of the total availability of resources (INCOME) and (the denominator in) the measure of the relative sectoral rates of return (SECPROF).

Figure 37 — Net cropped area, 1960-79



Source: Punjab, *Statistical Abstracts of Punjab* (Chandigarh: Economic and Statistical Organization, various years).

equation describes the distribution of the existing fertilizer supply to the various districts rather than changes in total supply.

To summarize, the results suggest that the decisions made by farmers regarding irrigation, and indirectly regarding net cropped area, were responsive to the increase in profitability spurred by the introduction of the MVs. The review in Chapter 3 shows that farmers also increased their investment in tractors. This suggests that the various components of physical capital were complementary and therefore expanded together.

A similar response to incentives was not found for the government decisions regarding investment in irrigation, although some response is detected for fertilizer. Even so, the level of these inputs, particularly fertilizers, increased over the same period. Chapter 3 indicates that the same is also true regarding the provision of electricity in the rural areas. Thus, one can conclude that the government has been responsive to economic incentives, but as expected, the exact decision process has not been revealed in the empirical analysis.

## The Long-run Path

The various equations of the system are now assembled in order to obtain the long-run response of the system to changes in the state variables. These responses will differ from the short-run responses discussed in Chapter 5. For instance, an increase in product price changes the differential returns in favor of agriculture. This causes an expansion of private irrigation, which in turn increases net cropped area. Changes in product prices also affect the differential returns to land across districts and thus affect the allocation of fertilizers to the various districts. Thus a change in product price affects acreage allocation, yield, and therefore output, directly as well as indirectly through the changes in the constraints just described. The change in yield, in turn, also affects the differential profitability of agriculture and thereby produces a secondary effect. The sum of all these effects can be obtained by inducing a shock to, and dynamically simulating, the system. By comparing the results derived from this exercise with the results from a (dynamic) base run, long-run elasticities can be obtained.

The results are reported in two parts. First, Table 21 presents the average elasticities of the quasi-fixed inputs with respect to a change in each of the prices, the availability of roads, and the availability of fertilizers. The most striking findings in Table 21 are the particularly large elasticities of net area irrigated by private sources with respect to each of the price variables and with respect to the two constraints. These large elasticities illustrate clearly that farmers responded positively and strongly to the changes in economic incentives over the study period.

Table 22 presents the average long-run output elasticities with respect to the same state variables. The long-run output elasticities with respect to price are all large (in absolute value) relative to their short-run counterparts. For instance, the elasticity with respect to wheat price is 0.784 for wheat output and 0.563 for aggregate output. The corresponding values for the same short-run elasticities are 0.107 and 0.066, respectively (Table 18). An increase in all prices by 1 percent leads to an increase in the output of all crops except gram. The average long-run elasticity of aggregate output with respect to a change in all real prices is 0.77 percent. This is a very sizable aggregate supply elasticity.

**Table 21— Average quasi-fixed input elasticities**

| Variable | PRIVATE IRRIGATION | GOVERNMENT IRRIGATION | AREA | FERTILIZER |
|---|---|---|---|---|
| Expected prices[a] | | | | |
| WHEAT | 0.944 | −0.047 | 0.027 | 0.268 |
| GRAM | 0.134 | −0.006 | 0.004 | 0.054 |
| RICE | 0.118 | −0.006 | 0.004 | 0.028 |
| COTTON | 0.073 | −0.004 | 0.002 | 0.032 |
| MAIZE | 0.124 | −0.006 | 0.003 | 0.036 |
| All prices | 1.395 | −0.070 | 0.040 | 0.419 |
| Constraints | | | | |
| ROADS[a] | 0.341 | −0.008 | 0.011 | 1.302 |
| FERTILIZER[b] | 0.256 | −0.007 | 0.008 | . . . |

[a] To calculate these elasticities, the full model was simulated with all quasi-fixed inputs endogenous (PRIVATE IRRIGATION, GOVERNMENT IRRIGATION, net cropped AREA, and FERTILIZER). Average elasticities for the sample period are reported.

[b] These elasticities are calculated by simulating the full model and fixing FERTILIZER = FERTILIZER (SAMPLE) × 1.01. All other quasi-fixed inputs (PRIVATE IRRIGATION, GOVERNMENT IRRIGATION, and net cropped AREA) are endogenous.

**Table 22 — Average long-run output elasticities**

| Variable | Wheat | Gram | Rice | Maize | Cotton | Production[a] |
|---|---|---|---|---|---|---|
| Expected prices[b] | | | | | | |
| WHEAT | 0.784 | -1.568 | 0.277 | 0.366 | 0.058 | 0.563 |
| GRAM | 0.061 | -0.318 | 0.038 | 0.041 | 0.028 | 0.013 |
| RICE | 0.082 | -0.148 | 0.164 | -0.013 | 0.041 | 0.093 |
| MAIZE | 0.085 | -0.132 | 0.016 | 0.221 | -0.024 | 0.069 |
| COTTON | 0.039 | -0.192 | 0.087 | -0.037 | 0.076 | 0.029 |
| All prices | 1.054 | -2.360 | 0.580 | 0.578 | 0.180 | 0.770 |
| Constraints | | | | | | |
| ROADS[b] | 0.443 | -0.458 | 1.111 | -0.153 | 0.153 | 0.436 |
| FERTILIZER[c] | 0.262 | -0.632 | 0.316 | 0.148 | -0.087 | 0.210 |

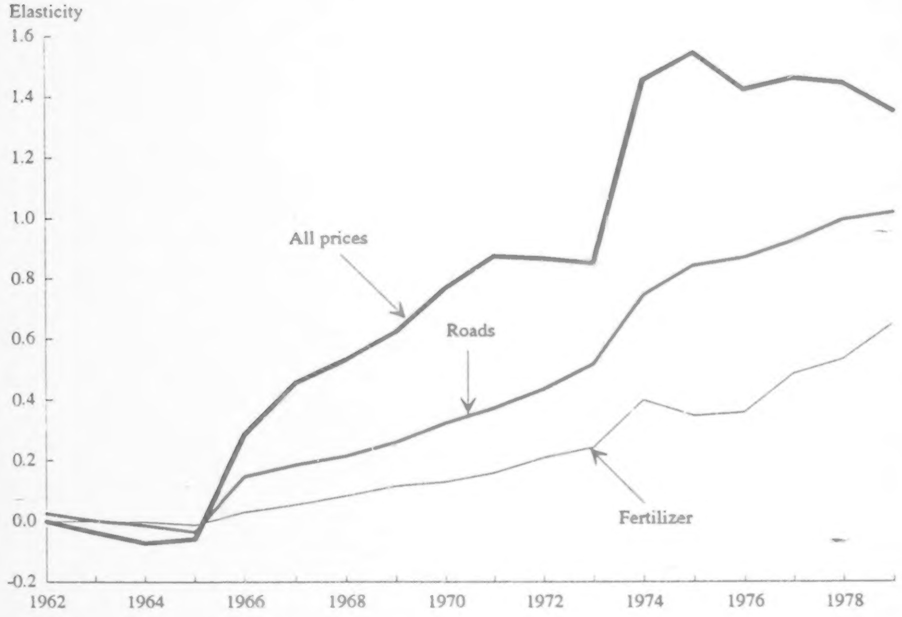
[a] Change in total production is calculated using a Normalized Quadratic Quantity Index (see Diewert 1976).
[b] To calculate these elasticities, the full model was simulated with all quasi-fixed inputs endogenous (PRIVATE IRRIGATION, GOVERNMENT IRRIGATION, net cropped AREA, and FERTILIZER). Average elasticities for the sample period are reported.
[c] These elasticities are calculated by simulating the full model and fixing FERTILIZER = FERTILIZER ×1.01. All other quasi-fixed inputs are endogenous.

Next, the time profile of the long-run responses is examined. The time paths of the aggregate output elasticities with respect to a change in all real prices (aggregate supply elasticity), a change in the availability of fertilizer, and a change in the availability of roads are all illustrated in Figure 38.

As indicated in Chapter 5, the response of the system to a shock in a state variable depends on the implemented technology. The more productive the implemented technology, the greater the response (in absolute value). This phenomenon is well illustrated by the plots of the aggregate output elasticities in Figure 38. Perhaps the most startling of all the results is the size of the aggregate supply elasticity toward the end of the transition period. Before the onset of the green revolution, the aggregate supply elasticity was close to zero, but by the time the transition to the MVs was, for the most part, complete, the aggregate elasticity of supply reached a level between 1.3 and 1.5. Similar results were found for the elasticities of aggregate output with respect to the availability of roads and fertilizers. Both of these elasticities were negligible in the early 1960s, but by the end of the period the elasticity of aggregate output with respect to fertilizers was 0.7 and the elasticity of aggregate output with respect to roads was 1.0. Very similar results were obtained for the other long-run elasticities.

One limitation of this study is that not all relevant capital inputs are included in the empirical model. An important question is what effect this omission has on the results obtained and the interpretations given. As the various forms of capital are largely complementary, it is likely that by omitting these variables, the coefficients on the included variables are biased upward and thus their elasticities are exaggerated. However, since the correlation between the various capital components is not perfect, not all the effects of the missing variables are taken into account. Therefore, the long-run output elasticities obtained tend to underestimate the actual elasticities. As the estimates of the elasticities calculated are already considerably higher than those obtained in conventional supply analyses, it may seem strange even to consider that the elasticities could be even higher. However, this is a bad criterion for assessing the reasonableness of the elasticities. As indicated in Mund-

Figure 38 —Long-run aggregate output elasticities with respect to state variables, 1962-79



lak 1988, if techniques coexist and factor prices remain constant, the transition to the more productive techniques will occur as the constraints to adoption are relaxed. The implication, of course, is that supply is perfectly elastic. This result is obtained under the assumption that factor prices remain unchanged in the transition process. Factor prices did not remain unchanged in Punjab as the factor supply curves are upward-sloping. Thus the product supply elasticities are smaller than infinity but very reasonable indeed.

## 7

# CONCLUSIONS

Much of the rapid growth in NDP experienced by Punjab during the period of study was generated by growth in agriculture. Most of this growth is attributed to growth in crop production resulting from improvements in the overall yields of wheat and rice and to a lesser extent from improvements in the yields of maize and cotton. The pattern of growth in overall yields for the various crops, particularly wheat and rice, suggests that the main improvements came as a result of a shift to modern higher-yielding varieties rather than as a result of intensifying the cultivation of existing varieties. Given that, in general, economic growth is driven by technical change, an understanding of the many factors that influenced the rate of implementation of new techniques in Punjab contributes to an understanding of agricultural growth.

In Punjab, the shift to MV wheat and rice was very fast. The first year the modern wheat varieties were introduced they were sown to 30 percent of the total wheat area. This proportion increased to 70 percent by only the third year. The experience in rice was similar, once suitable rice varieties were introduced. The extremely rapid adoption of MV wheat and rice indicates that factors usually associated with the rate of implementation of new techniques, such as imperfect information, uncertainty, institutional constraints, and inadequate human capital, did not play a prominent role in the adoption process. That is, these factors could not have changed much over the extremely short transition period, and therefore could not have influenced the rate of adoption. Alternatively, the speed at which the new varieties were implemented suggests that the pace of transition was largely determined by the productivity of the MVs relative to the traditional varieties and the existence of physical constraints.

To assess the relevance of this working hypothesis, the growth in Punjab agriculture is modeled utilizing a choice-of-technique framework. Given that much of the agricultural growth can be attributed to the implementation of new techniques of production, a complete understanding of the growth process requires that the factors affecting the decision to implement these techniques be identified explicitly.

The techniques analyzed are the major crops in Punjab, identified by variety, season of growth, and method of production (dry versus irrigated). It is hypothesized that in the short-run, area allocation decisions are influenced by the expected revenues of the different techniques; the availability of fertilizers, irrigation, and cropped area; and the local environment. Overall yields by crop are assumed to be determined by the composition of techniques implemented, the availability of fertilizers, and the local physical environment. The effect of the local physical environment, the initial levels of infrastructure, and the availability of human capital on choice of technique and overall level of output are detected by the inclusion of fixed district effects.

Because resources are scarce and therefore have to be attracted to agriculture from other uses, changes in the availability of fertilizers, irrigation, and cropped area are hypothesized to depend on the overall availability of resources and the differential rate of return between agriculture and nonagriculture. The relative importance of these factors depends on whether the decisions are made by the public or private sector. Equations analyzing the investment decisions of both the private and public sectors are estimated simultaneously with the area allocation and yield equations.

The results are summarized by deriving both short-run and long-run elasticities. The specification of the model implies that the size of both the short-run and long-run elasticities depends on the productivity of the implemented technology; the more productive the implemented technology, the greater are the elasticities (in absolute value).

The short-run area elasticities by technique indicate that changes in the availability of quasi-fixed inputs have very significant intertechnique effects. In particular, the pace of the transition to the MVs of both wheat and rice is positively influenced by the availability of all quasi-fixed inputs. Further, given fixed levels of the quasi-fixed inputs, changes in incentives lead to important changes in the composition of techniques. Increases in the expected revenue of the superior varieties of all crops, whether due to an increase in expected price or yield, encourage the adoption of these varieties. This finding suggests that if the real price of wheat and rice had not been declining over the period of study (see Chapter 3), the transition to the MVs would have been even more rapid.

Even though the response to incentives was important, the magnitude of the elasticities suggests that intertechnique effects due to changes in the availability of quasi-fixed inputs are often severalfold larger than the same elasticities due to changes in the incentives (in absolute value). The availability of private irrigation and roads appears to have been particularly important in the transition process. The area allocation results also indicate that the competition between techniques as the availability of resources and incentives changed differed by crop and season.

The importance of the intertechnique results is reinforced by the yield results, which indicate that the choice of implemented techniques largely determines overall yield by crop. In addition, the (fixed) local environment has a significant influence on yield levels.

For the most part, the short-run output elasticities reiterate the area results in indicating that the availability of quasi-fixed inputs played a major role in the determination of the growth of output; the magnitude of the output elasticities with respect to the quasi-fixed inputs is large relative to their price counterparts.

The short-run aggregate output elasticity with respect to a change in all (real) prices increased from nearly zero before the onset of the green revolution to a high of 0.18 in 1979, when the transition to the MVs of wheat and rice was largely complete. Thus, conditional on the availability of quasi-fixed inputs, aggregate agricultural output does not respond much to a change in price.

The results from the quasi-fixed input equations suggest that the decisions made by farmers regarding irrigation, and indirectly regarding net cropped area, were responsive to the increase in profitability spurred by the introduction of the

MVs. The long-run elasticities of area irrigated by private resources with respect to prices and the availability of roads and fertilizers were particularly large.

Although similar responses were not obtained in the government investment equations as specified, the observed increases in the provision of electricity and the availability of fertilizers and roads suggest that the government has responded to economic incentives.

The long-run output elasticities with respect to prices are all large relative to their short-run counterparts. These elasticities reflect the strong response of private irrigation and the somewhat more moderate response of net cropped area and fertilizers as incentives changed. The long-run aggregate supply elasticity, although negligible before the onset of the green revolution, reached a high between 1.3 and 1.5 in the late 1970s. Although these aggregate supply elasticities are large relative to those obtained in other studies that do not model explicitly the choice of technique and change in the availability of resources, they make sense given the conceptual framework of this study.

Given the results of this study, one can conclude that as long as expansions in irrigation facilities and fertilizers are possible and lead to further adoption of the more productive techniques, aggregate agricultural output will continue to respond significantly to changes in economic incentives. However, once the transition to the new varieties is fully played out, stagnation will occur. Once stagnation occurs, further substantial growth in agricultural output will require the introduction of new higher-valued techniques and products. If these new techniques are more capital-intensive than the previously implemented techniques, the rate of capital accumulation will continue to play a critical role in the growth of agriculture.

# APPENDIX 1: ADJUSTMENTS FOR BOUNDARY CHANGES

Based on data published in the *Statistical Abstracts of Punjab*, the total area in each of the various districts of Punjab has changed continually over time. Although most changes have been negligible, substantial changes occurred in the districts of Hoshiarpur, Sangrur, Ferozepore, and Bhatinda during the sample period.

Although it is unclear exactly when the division occurred, the districts of Ferozepore and Bhatinda were split into the three districts of Ferozepore, Bhatinda, and Faridkot. Data for both Ferozepore and Bhatinda before 1971 include the data for area that is now in Faridkot. Rather than disentangle these data and try to recover the data for Faridkot, the data published for Faridkot in years after 1971 are divided between Ferozepore and Bhatinda according to the area in Faridkot that originated in each of these districts. That is, approximately 70 percent of the area in the new district of Faridkot was originally in the district of Ferozepore; thus, 70 percent of each area series reported for Faridkot is added to the same area series in Ferozepore, while the remainder (30 percent) is added to the Bhatinda data, as approximately 30 percent of the area in the present district of Faridkot originated from the old district of Bhatinda.

The area of Hoshiarpur and Sangrur decreased 32 and 34 percent, respectively, during the division of erstwhile Punjab into present-day Punjab and Haryana in 1966. For the purpose of this study, the present-day districts of Hoshiarpur and Sangrur are analyzed. Thus the pre-1965 data are adjusted to make the older data series consistent with the more recent data. For the most part, the data obtained were already adjusted for the changes that occurred. For Sangrur, for example, all data appeared to be adjusted, and thus consistent with the present-day data series, with the exception of data on area sown to wheat. To determine how to adjust these data, an adjusted series and an "old" series of gross cropped area available for the years 1960-64 were compared. Based on these comparisons, it appeared that an adjustment factor of 0.65 was used to make the pre-1966 data consistent with the more recent data. The remaining unadjusted data for Sangrur were adjusted using this adjustment factor. Similarly, all unadjusted data for Hoshiarpur in the pre-1966 years were adjusted using an adjustment factor of 0.77, calculated in a manner identical to that described above for Sangrur. Unfortunately, further checks of the data for Hoshiarpur indicated problems in the irrigation data for the years 1968-1972. In particular, unreasonable numbers were obtained for irrigation intensity (gross irrigated area divided by net irrigated area). Thus the data for this district were ultimately dropped from the analysis.

# APPENDIX 2: DERIVATION OF AREA AND EXPECTED YIELDS BY TECHNIQUE

## Derivation of Area

Over the period of the study, new varieties were introduced for many of the crops. The most significant changes occurred in both rice and wheat and to a smaller extent in maize. Information is available on area planted to these new varieties.

For the purpose of this model, the assumption is made that there are three techniques of production for wheat and rice. The three techniques include an irrigated modern variety (MV) and two traditional varieties (irrigated and dry). Given the assumption that all MVs in Punjab are irrigated, the disaggregation of wheat and rice into these three varieties is straightforward. That is, data are available for the total area planted to each crop, total area irrigated for each crop, and area planted to MVs for each crop. Using this information and the assumption that all MVs are irrigated, area allocated to each technique of wheat is calculated as follows:

$$\text{MV Wheat Area} = \text{MV Wheat Area (Given)}, \tag{32}$$

$$\text{Irrigated Traditional Wheat Area} = \text{Total Irrigated Wheat Area} - \text{MV Wheat Area, and} \tag{33}$$

$$\text{Dry Traditional Wheat Area} = \text{Total Wheat Area} - \text{Total Irrigated Wheat Area.} \tag{34}$$

Similar calculations are made to disaggregate rice area by variety. With the exception of a few negative numbers obtained for irrigated traditional wheat and rice area (equation [33]), the data derived as the result of this disaggregation process indicate that the assumption is reasonable. It is assumed that the negative numbers indicate that some MVs are also planted on dry land. (Alternatively, the negative numbers may be indicating problems with the data.) Because the negative numbers were generally small—relative to the total area sown to wheat (rice)—rather than disaggregating the MV wheat (rice) area into two activities (irrigated MV and dry MV), the assumption that all MVs are grown on irrigated land is maintained; irrigated traditional wheat (rice) area is set equal to zero, and the amount of dry traditional wheat (rice) calculated by equation (34) is reduced by the amount of dry land presumed to be planted to dry MVs.

For the remaining crops (maize, cotton, and gram), the assumption is made that there are only two techniques of production, irrigated and dry traditional varieties. Area allocated to the dry traditional varieties is derived as in equation (34), and total area irrigated by crop is given in the original data.

Although information regarding adoption of maize MVs is available, production of maize is only disaggregated into irrigated and dry techniques because the extent to which these new varieties have been accepted has been relatively minor and has fluctuated over time. A large part of this varied success is explained by the unreliable yields of the newer varieties and the problems some of these varieties have experienced with disease and drought. Because the data required to study the effect of these problems on the rate of adoption of the new varieties are not available in the data base, the distinction between irrigated varieties is not made.

## Expected Yields: Traditional Varieties

A full series of data on yield by variety is not available for the traditional varieties. Data from *Farm Accounts in Punjab* are used to construct these variables. The data provided in this series are the result of a survey of 32 nonmechanized holdings throughout Punjab. Although the sample is notably small and the holdings surveyed have changed over the years, this study relies on the assumption that the data "indicate, within reasonable limits, trends or relative changes that take place from year to year in the financial position of the farmers" (*Farm Accounts in Punjab, 1975/76*, p.6). Data are available from *Farm Accounts in Punjab* for the following years: 1960-69, 1972, 1975, and 1979, by geographical region.[32] Separate yields for each crop are given for irrigated and unirrigated areas. Because the series is not complete, the construction of the yield variables from these data involved manipulation of the available data and several assumptions.

In general, expected yields for each traditional variety (irrigated and dry) for all years and all districts were obtained by regressing the available or relevant data on regional intercept shifters and a time trend. Regional intercept shifters are incorporated to allow expected yields to vary across regions, and a time trend is incorporated to allow for the possible improvement over time of the different techniques of production. The significance of the fixed regional effects and the time trend was assessed using an F-test or a t-test. With the exception of the irrigated maize yield, the regression results suggest that the yields of the traditional varieties have not changed significantly over time. The increase in irrigated maize yield undoubtedly reflects the introduction of improved varieties of maize during the period of study. The fixed regional effects were significant in every equation except irrigated gram and irrigated traditional wheat. Thus, for all varieties except irrigated gram, irrigated traditional wheat, and maize, the average regional yield of each traditional variety is used as an indication of the expected yield. The expected irrigated maize yields were calculated by taking into account the significant regional effects and the significant trend variable. Given the lack of significant regional effects and time trend, the expected irrigated gram and traditional wheat yields were calculated by averaging the available data over time and across all districts. The expected yields calculated for each variety are detailed below.

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[32] In *Farm Accounts in Punjab*, Punjab is divided into three physical regions closely corresponding to those discussed in Chapter 3. Region 1 corresponds to the hilly area and includes the districts of Hoshiarpur and Gurdaspur; region 2 is the central plains area and includes the districts of Amritsar, Jullundur, Kapurthala, Ludhiana, and Patiala; and region 3 comprises the southwestern districts of Ferozepore, Bhatinda, and Sangrur.

**Wheat: Dry Traditional Yield**

The available regional yield data for unirrigated wheat (1960-66) were used to calculate the following expected yields (tons per hectare):

Region 1: 0.884 Region 2: 0.711 Region 3: 0.541

**Wheat: Irrigated Traditional Yield**

Regional yield data for irrigated wheat (1960-66) were used to calculate the following expected yields (tons per hectare):[33]

Region 1: 1.249 Region 2: 1.249 Region 3: 1.249

**Rice: Dry Traditional Yield**

Dry rice yields are available only for region 1 (the area with the highest rainfall) in *Farm Accounts in Punjab*, yet some rice is grown in other regions. To calculate a yield for the other two regions the average (dry) yield from region 1 (1960-66) is used as a base, and the region 2 and region 3 yields are calculated using the regional effects obtained from the dry gram results (see below). The gram regional effects are used rather than the more likely choice of maize, as the gram calculations are based on a larger number of observations.[34] Thus the expected yields (tons per hectare) are

Region 1: 1.09 Region 2: 0.606 Region 3: 0.594

**Rice: Irrigated Traditional Yield**

As with irrigated traditional wheat, only regional yield data for 1960-66 were used to calculate the following expected yields (tons per hectare):

Region 1: 1.49 Region 2: 1.24 Region 3: 1.29

**Maize: Dry Traditional Yield**

A full series of data required for this calculation is available for regions 1 and 2. Data for region 3 are available only for two years. The average yields for regions 1 and 2 are used as the expected yield for these regions. The two data points available for region 3 are compared with the average yield over the same years for region 1. The average yield of region 3 is 0.92 times that of region 1. This figure (0.92) is used to adjust the average yield of region 1 for the whole sample (1960-66) to obtain a yield for region 3. The resulting expected yields (tons per hectare) are

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[33] Other data were available but not used, as it is assumed that after 1966 the irrigated wheat yields reflect a mix of both traditional varieties and MVs.

[34] Maize is a better choice, as it is grown in the same season; however, the region 3 effect may not be reliable, as data available are sparse. Further, the regional effects for gram and maize (dry) yields are very similar for regions 1 and 2, where data are more abundant. Thus, the more reliable region 3 effect for gram is used.

Region 1: 1.26 Region 2: 0.68 Region 3: 1.16

### Maize: Irrigated Yield

Because the irrigated maize category includes a combination of both traditional varieties and MVs, the calculation of expected yield is not limited to pre-1967 years. However, the availability of data does limit the analysis to the years 1960-69, 1972, 1975, and 1979. The results from the regression of all the available yield data on the regional intercept shifters and time trend indicate that both effects are significantly different than zero. Based on the results obtained, the expected yields (tons per hectare) are (1960, t =1)

Region 1: 0.919 + .036t Region 2: 1.17 + .036t Region 3: 0.58 + .036t

### Cotton Yields

Expected yields are calculated separately for each variety of cotton. The final expected irrigated and dry cotton yields are calculated by weighting the yields described below by the proportion of cotton acreage planted to each variety.

### Desi Cotton: Dry Yield

A full data series on unirrigated Desi cotton yields are available only for region 1 (1960-69, 1972, 1975, and 1979). The regression of these yields on a time trend indicates that the time trend is not important. Region 2 yield data are available for four years only and data for region 3 exist for only three years. Expected yields for these regions are calculated using an approach identical to that used to calculate dry maize yield for region 3. Based on the results obtained, the expected yields (tons per hectare) are

Region 1: 0.445 Region 2: 0.383 Region 3: 0.435

### Desi Cotton: Irrigated Yield

Yield data from all three regions over the years 1960-69, 1972, 1975, and 1979 were used to obtain the following expected yields (tons per hectare):

Region 1: 0.485 Region 2: 0.592 Region 3: 0.596

### American Cotton: Dry Yield

As with dry Desi cotton, a full yield series is available only for region 1. No yield data are available for the other two regions. The regression of yield data from region 1 on a time trend indicates that the yields do not change significantly over time. The regional effects for the Desi dry yields are used to obtain expected yields for the other two regions using the calculated yield for region 1 as a base. The resulting expected yields (tons per hectare) are

Region 1: 0.539 Region 2: 0.464 Region 3: 0.527

**American Cotton: Irrigated Yield**

Irrigated American cotton yields are available only for region 2 and region 3. Regression results suggest that only the regional effect is significant. Using the regional effects obtained in the analysis of Desi cotton (irrigated) yields and the expected American cotton (irrigated) yield for region 2 as a base, a yield for region 1 is derived. The resulting expected yields (tons per hectare) are

Region 1: 0.546    Region 2: 0.666    Region 3: 0.823

**Gram: Dry Yield**

Data are available for dry gram yield in all regions for the following years: 1960-69, 1975, and 1979. Based on these data the expected yields (tons per hectare) are

Region 1: 0.910    Region 2: 0.506    Region 3: 0.496

**Gram: Irrigated Yield**

Data are available only for regions 2 and 3 for the years 1960-69, 1975, and 1979. Given that both the time trend and the regional fixed effects were insignificant, the expected irrigated gram yield is assumed to be the same in all regions. The expected irrigated gram yield is 0.645 tons per hectare.

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